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SEPTEMBER, 1916

THE SCIENTIFIC INVESTIGATION OF CANCER

By Dr. LEO LOEB

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WE may treat the subject of cancer from two points of view, namely, from that of the scientific investigator who studies it as a natural phenomenon and ascertains the laws of its origin and development, and from that of applied science, medicine, which is mainly concerned with the eradication of the disease. In the natural course of events, scientific analysis must precede the utilitarian attempts at control. I shall treat the subject of cancer purely from the viewpoint of scientific analysis. This analysis is not yet completed and on this occasion I shall endeavor to tell something of what science has discovered about cancer, following a study which really does not date much further back than twenty years.

Scientific investigation starts with the most obvious and gradually penetrates into the more remote. Experiences are the starting point for investigation; experiences that call forth pain or pleasure, especially those that call forth pain, which do not fit into the rest of our life, which disturb its real or imagined harmony. In its origin, therefore, science is utilitarian. It is a direct struggle with the enemies of our peace of mind and of our body. Only gradually, through the greater maturity of our experiences, does reality become the object of our interests in this struggle with the emotions, and from now on we are no longer guided directly by them in our investigations, but the latter become transformed into a dispassionate search for the relations of facts. We seek to complete the picture of reality which at first was only a by-product of other efforts. This now becomes our real problem. The investigations have passed beyond the primitive, utilitarian stage. Eventually, however, this study of reality for its own sake leads to results which again serve our utilitarian purposes better than a direct attack of the problems from a so-called "practical" point of view. Wireless telegraphy, diphtheria antitoxin, the eradication of yellow fever were possible only on the basis of purely scientific analysis, such as is carried on in the case of cancer research at the present day. The

greatest technical progress has been accomplished and may be expected to bring the best results in the future by attacking the problem on the basis of a dispassionate philosophical analysis of reality. This analysis transforms thunder and lightning, which at first called forth only feelings of awe and fear, into phenomena of electricity, acoustics and optics, and teaches us their oneness with the phenomena which help to maintain life. The growth of bacteria, which cause disease and death, on the one hand, is seen to play a wider rôle in the economy of life, to be indispensable for the maintenance of life in the higher animals.

It is not otherwise with the subject on which I have been asked to write. What at first we consider a disease, a scourge which fills us with fear and despair, will be seen to be but a particular phenomenon of growth comparable in a certain respect to the development of the egg into the adult, to the restitution of an extremity in one of the more primitive amphibia and to the healing of the wound in a human body after a cut or a bruise.

In cancer we deal with an essentially similar phenomenon—with the multiplication of the small units of our body, the cells. In a definite, usually sharply circumscribed and relatively small area such cells begin to proliferate; they multiply to an unusual degree; they make their way into the deeper parts of the body, destroy the neighboring tissues, penetrate often into lymphatics or blood vessels, are carried to distant parts of the body—lung, liver or elsewhere—settle here and give origin to secondary growths, the so-called metastases. Not all new formations of this kind, which are generally called tumors, are equally destructive. Some merely grow slowly and form a prominence without penetrating into neighboring tissues. These are the so-called benign tumors. The destructive tumors are called cancers. Almost any tissue in the body, almost any cells may, under certain conditions, begin to grow in this malignant, cancerous manner and, according to the kinds of cells that have thus proliferated, different types of cancer have been distinguished, as, for instance, *carcinoma*—the cancer of the cells covering the surface of the body and the body cavities, the epithelial cells; and *sarcoma*—the cancer of the tissues connecting the various surface and glandular structures of the body. But these are, for our purposes, differences of minor importance. The essential fact is this: in cancer we are dealing with a cell multiplication similar to that which leads to the building up of the normal organism, the difference between normal growth and cancerous growth being as follows:

During the development from the egg to the adult organism, the multiplying cells and the developing tissues show a definite relation to one another, which is essentially hereditarily fixed. In cancer, however, certain cells or tissues fall out of this normal scheme of predetermined

growth; they are no longer kept in bounds through the agencies which restrain the development of other parts of the body, and this leads to the formation of monstrosities. We may then conclude that the same laws which ultimately determine all cell and tissue growth also underlie cancerous growth. These laws are fundamentally those regulating the physical and chemical changes which take place in the protoplasm. But added to these *general* causes of growth, which cancer has in common with embryonic development and the process of repair after the loss of parts of the body—the so-called regenerative growth—there must be a special factor which is responsible for the excessive growth-energy and destructive capacity of certain tissues or cells in the body which distinguishes them as cancerous growths from other kinds of growths. To find this special factor or rather this special set of factors constitutes the fundamental cancer problem.

In my introductory remarks I stated that certain experiences in life of a more or less emotional character are the starting point for investigation, and that only gradually do these investigations become dispassionate, objective, do they come into contact with neighboring fields of research and broaden into an attempt to understand reality. Hand in hand with this enlargement of the concept of the problem we find a simultaneous widening of the range of objects now considered as more or less related to the original object of investigation, and a greater refinement in the methods of research. At first only human cancer was considered. It is only recently that we turned with interest to other organisms and discovered that cancer exists in all classes of vertebrates—although with unequal frequency—and that somewhat related phenomena are even to be observed in plants. At first we were satisfied with the observation of human tissues with the naked eye and with statistics concerning the frequency and distribution of human cancer; later there were added microscopic investigations with gradually accumulating refinements. These in turn were reinforced with experimental methods in which were recorded observations of the growth of cancers in animals which had been inoculated with tumor. And then we began to study experimentally the conditions under which cancer developed spontaneously and under which the development of spontaneous cancer can be prevented in animals, and the reactions of normal tissues under various abnormal conditions.

The experimental study of cancer is as necessary as the experimental study of all other problems. Mere observation confronts us usually with a considerable number of variable factors, and when we observe a sequence to a certain group of factors, observation alone does not usually permit us to decide which factors are really causative and which merely accidental. Through experiment we can at will isolate or combine various factors and thus alone find the real causes. Ex-

perimentation in the case of cancer does not only consist in the artificial inoculation of cancer—which, by the way, is technically not very different from the injections of substances under the skin in human beings, and therefore not very painful—but also in the systematic breeding of certain animals and in varying the conditions of life in which animals are kept. In this way problems can be solved whose solution can hardly be attained if we restrict ourselves to observations of human cancer, because of the complicated conditions found in human society.

We have now determined what is meant by tumor and cancer, the general distribution of cancer and the methods of investigating the cancer problem. Let us then follow the threads of investigation a little farther and consider some of the results obtained by experimental means. Here we will take up in turn the three problems, namely, the conditions that lead to cancer, the reaction which takes place in the body against cancer growth, and lastly some properties of cancer cells—and secondarily of normal cells—which have been discovered as a result of cancer investigations.

In analyzing the origin of certain phenomena, we are apt to take one definite circumstance as the cause of a succeeding event. This is the procedure which we usually follow in our daily life. But a more careful analysis of any phenomenon will usually reveal to us the very much more complicated relation it bears to other phenomena. The more we search, the more apt we are to find that there are a number or rather a multitude of factors which at the very beginning work together, shaping the event which interests us. Among these factors we can discern some which seems to us of greater importance, more specifically related to the event under discussion and others which apply not alone to this specific event or to a relatively restricted number of events, but equally well to a large number of other experiences, not necessarily related to the one under consideration. For instance, to mention a factor belonging to the second category, the temperature which is required to sustain life processes in general and therefore also in particular cancer growth. The relation between temperature and cancer growth is therefore not a specific one, but one which cancer growth shares with other life processes. While a certain temperature, then, is one of the conditions necessary for the development of cancer, it is not a specific condition and therefore not a cause in the strictest sense of the word.

We know that not one single factor is the cause of cancer, but we have discovered a number of conditions all more or less specifically related to cancer growth. Provisionally these may be divided into two classes, namely, internal and external factors. By internal factors we mean such as are operative within the organism, apparently conditioned

mainly by the organization of the animal and at a place not accessible to a direct experimental change. The external factors consist of conditions operative in the environment of the cells which give origin to cancer, either within or without the whole organism of which the cancer cells form a part. The external factors are more accessible to experimental control than the internal. The external factors which set up changes in the cells and tissues are usually only the first link in the chain of circumstances which ultimately ends in the production of cancer. And this link we may generally call a *stimulus*.

Let us then first consider some of the internal factors and later the external factors which lead to cancer growth. One of the most important internal factors which has been thoroughly established within recent years, at least in the case of animal cancer, is heredity. Our attention was first drawn to the possibility that heredity might play a part in the origin of cancer, through observations which we as well as other investigators, made some eighteen years ago. It was found that a surprising multiplicity of cancers occurred in certain cages in which animals were kept, especially rats and mice, and that the varieties of cancer which appeared under those conditions were in each case identical. This led to the conclusion that cancer was so often found in those cages because the animals living there belonged to the same family.

There are other possible explanations for the frequent occurrence of cancer in animals kept in the same cage or breeding place. It might have been that the cancer spread through infection from one animal to another. Indeed, in the case of man, the alleged greater frequency of cancer in certain regions has been explained by some observers on the basis of the infectiousness of cancer. However, I may state here that no undisputed case, in animals or in man, has ever been recorded where cancer was known to have spread through infection caused by a microorganism. This lack of infectiousness, however, does not entirely exclude the possibility of the presence of microorganisms in certain cancers—a possibility to which I shall have occasion to refer later. There are certain cases in which metazoic parasites are undoubtedly responsible for the so-called "endemic" occurrence. We have, however, been able to decide the question as to the usual cause of the occurrence of identical cancerous growths in animals by showing that hereditary conditions play a paramount rôle. For this purpose we used mice, which are perhaps most suited to such experiments, since they are not long-lived animals. We kept them in families separated from each other throughout a number of years, but otherwise absolutely under the same conditions as far as climate and food were concerned. Now we found that each family had a definite cancer rate which remained approximately ***constant throughout succeeding generations.*** While in some strains cancer

occurred in about 70 per cent. of all females, in others it occurred in only 2 to 3 per cent. If we crossed two mice belonging to strains with different cancer rates, we found that in a considerable number of cases the offspring followed approximately the cancer rate of the parent with the higher cancer percentage; in other cases, however, the offspring followed the parent with the lower cancer percentage. *There is therefore not the least doubt that cancer in animals is hereditary.* And not only is the cancer frequency hereditary, but *also the* age at which cancer most frequently appears in each family. The hereditary transmission of the cancer age is independent of the frequency. Thus it may occur that if we compare two families we may find that cancer is about equally frequent in both, but that it appears in one most frequently in middle life, while in the other it usually develops in later life. And these conditions are constant in succeeding generations.

Does this conclusion apply equally to cancer in man? The complicated conditions in human society make it very difficult to interpret statistical data with the same definiteness as in the case of animals. There are, however, indications which make it very probable that *in man also heredity is a definite factor.* We know that some races are almost immune to cancer, as, for instance, the American Indian, the Negro in Africa, and some aborigines of Australia and the South Sea Islands. It is very probable that this immunity to cancer is not due to the differences in food or to climatic conditions. Europeans removing to these regions are not immune. Furthermore, we note that the negro in America has a much higher cancer rate than the negro in Africa. This may possibly be referable to the interbreeding which has taken place among the negroes and whites in this country. Definite data for man which could answer this question are, however, lacking, and until more exact investigations in this direction can be undertaken we must abstain from making final decisions as to this point. The observation that among white people the cancer rate differs relatively little in various civilized countries does not speak against the existence of a heredity factor. It might merely indicate that the hereditary disposition to cancer is about equal in different families or strains. Furthermore, in human society intermarriages have been so constant and so frequent that differences between various families which might have existed to a greater degree at earlier stages of development may gradually have been eliminated or obscured. It is, however, well known that in certain human families cancer has been very frequent. Only recently a very interesting observation was published concerning two sisters, who died within a very short time of one another, and were both found to have been affected by the same *very rare kind* of cancer. While it is perhaps possible to explain all such occurrences among human beings as referable to the laws of chance, the facts established

in the case of animals rather suggest that in human cases too heredity may be an important cause.

There are other conditions which may under certain circumstances act as internal factors. In the human being certain very peculiar tumors are found which by their general appearance recall the structure of embryonic tissues. By embryonic tissue we mean those structures which are intermediate between the ovum and the adult organism. These tumors are therefore called embryomata and they are found especially within the generative glands. It has been recently observed that eggs within the generative glands may begin spontaneously to undergo a certain development—to develop without fertilization. According to our observations such a development may proceed even to the early formation of the central nervous system. Such structures are, however, usually destroyed after a period of temporary growth; but it seems that under certain conditions they can develop into malignant tumors, malignant embryomata, or teratomata. The factors therefore which favor the fargoing parthenogenetic development of the ova must be considered as in some cases playing the part of internal factors leading to the production of cancer.

Developmental malformation is a third factor which may cause cancer. These tumors are frequently found at an early age, but they may become apparent only in later life. In either case they originate during the period of embryonic development. We know that developmental errors are not infrequently found in man as well as in animals. Not rarely cells are misplaced, partly or entirely separated from the normal environment. In most cases such abnormally placed cells do not result in serious consequences, but, in some, as we have said, they become the starting point for malignant tumors. Pigmented moles may be considered as developmental errors and it is a well-known fact that under certain conditions favorable to cancerous growth they have become malignant tumors. Thus again *indirectly* may heredity play a part in the origin of cancer.

External Factors

Let us now briefly consider the external factors to which we referred. Generally speaking any mechanical stimulus acting over a long period of time and leading to inflammatory conditions may produce cancer. Thus we know that long-continued burning of the skin by carrying stoves, as the natives of Kashmir do, and long-continued action of Roentgen rays, extending over a number of years without the available precautionary means, have led, in many cases, to the production of cancer. Chemical stimuli also may lead to cancer. It is well known that in certain trades cancer is more frequent because of the action of the chemicals used. Paraffin workers are not rarely affected by cancer

of the skin; aniline workers develop cancer of the bladder. But more interesting than these general chemical actions is the fact that certain chemical substances given off by organs within the body which normally have a stimulating action on the growth of certain tissues may on the strength of this stimulating action be factors favorable to the development of cancer. Thus it has been recently demonstrated that extirpation of the ovaries in animals at a certain period of their life may greatly reduce the occurrence of cancer of the breast in those animals. This is, in all probability, due to the fact that a certain substance given off by the ovary which normally stimulates the growth of the mammary gland is removed through the extirpation of the ovaries. Apparently any external condition which causes long-continued growth processes in cells may in consequence of this stimulating action be a factor in the origin of cancer, and if we learn to eliminate such action we may to some extent prevent the development of cancer in a certain percentage of cases.

We have now learned of a number of causes for this abnormal cell proliferation which we call cancer. We know furthermore that internal and external factors must cooperate in the development of cancerous tissue. But it is very probable that the ratio between the number of internal and external factors necessary to obtain definite results is not fixed. The larger the number of external factors the smaller, in all probability, need the requisite number of internal factors be. For instance, it is probable that very long-continued action of Roentgen rays may lead to the production of cancer in persons in whom the heredity factor may be very weak.

Stimuli, such as those which lead to the production of cancer, chemical as well as mechanical, also cause growth processes in normal tissue. We know that in lower animals parts of the body which have been lost, may be replaced; that in higher animals wounds will heal; that certain chemical substances call forth growth processes which are not cancer. For instance, the placenta, through which the fetus is attached to the mother, grows in response to a combined action of chemical and mechanical stimuli; ova can develop parthenogenetically (without fertilization) under the influence of various stimuli. But in all those cases the stimulus leads to only a temporary proliferative activity of the cells and tissues. Sooner or later, the tissues return to their former equilibrium in which proliferation is very limited or entirely absent. It is not so in cancer. Cells which through various agencies have once become cancerous may be destroyed; but where they are not exterminated, provided sufficient nourishment is obtainable and other conditions necessary to their growth permit it, they proliferate eternally. Cancer cells, then, differ from normal cells in so far as the stimulus which in normal cells produces only a temporary growth, in the

cancerous transformation produces an endless increase in cell proliferation. In most cases cancer cells as well as normal cells are, as far as we can determine now, potentially immortal, which means that, given proper conditions for existence, they can live indefinitely and survive indefinitely the organism of which at one time they formed a part. Certain normal tissues may also not only live indefinitely, but also grow indefinitely, and cancerous cells differ from normal cells merely in their excessive proliferative function and in their greater power to attack the deeper tissues. This surplus power has been attained under the influence of the external stimuli which we mentioned before, with or without the cooperation of the internal factors.

The essential problem then is: How does it come about that under certain conditions stimuli which apparently are only temporary lead to changes which continue indefinitely after the stimulus has ceased to act? We must assume then that the organization of the cell has changed from one equilibrium—that of the normal cell—to another, which latter is characterized by greater proliferative activity and a greater power to penetrate into deeper tissues. The organization of some cells has been changed under the influence of growth stimuli and they are now somehow machines of a different character, which react differently to external factors. We might call such a transformation a mutation, and we have analogies for such a change in similar transformations which may suddenly occur in germ cells and lead to the production of new varieties and species. We have also in the case of ordinary tissue cells (in contradistinction to germ cells) some evidences that certain changes induced by external factors may be transmitted at least in some degree to succeeding generations of ordinary tissue cells. This is true of tissue cells as well as of germ cells; for tissue cells are potentially similarly affected as cancer cells. It is obvious then that one explanation for the origin of cancer may be the following. All or almost all normal cells possess two equilibria: (1) the equilibrium which is manifested under ordinary conditions, in which the cell has a limited proliferative power and (2) an equilibrium in which the cell has a greater proliferative power. A normal cell which has been changed from the first to the second equilibrium we call a cancer cell.

There is, however, another alternative in explaining the cancerous transformation, which would in certain respects furnish a simpler explanation. If we assume that in addition to the conditions which are important for the origin of cancer (namely, the internal and external factors before mentioned), there is hidden a constantly acting stimulus within the tumor, then the reaction of the tumor cell would be essentially similar to that of any normal cell. The tumor cell would react constantly through an increased proliferative activity merely as a result of an eternally acting stimulus. Such a continuous active stimu-

lus working through an agent external to the cancer cell could only be supplied by a microorganism constantly at work within the tumor. By microorganism we mean a very small living organism of either plant or animal character which can be seen only microscopically and which is sometimes so small as to escape detection even under the microscope. The smallest organisms of this kind are able to pass through a filter which retains ordinary bacteria. We know, in fact, that certain microorganisms may cause tumor-like cell proliferations, especially in plants. Certain plant tumors have been shown to be definitely caused by bacteria. In the case of animal tumors the proof that microorganisms are present has so far not been definitely established. We know, however, of very interesting experiments in which tumors have been produced artificially without a transfer of the tumor cells themselves. In ordinary experiments we can readily transfer tumor cells from one individual to another, of the same species, and thus cause in the second individual the growth of the same kind of tumor. Above, in speaking of these artificially produced cancers, I had not in mind the sort that are produced by transmission of cancerous cells, but I referred especially to experiments carried out by Peyton Rous with certain *bird* cancers in which *filtrates* of the bird cancer *free from living cells* appeared to call forth the production of new similar tumors. There are other experiments on record in which the introduction of one kind of tumor stimulated the cells of the animal to the production of another kind. These results can be explained only in one of two ways: either extremely small microorganisms were transferred with the tumor filtrate, or a certain chemical substance which stimulated the tumor cells to proliferate and which was constantly produced within the tumor cells was transferred with the filtrates, or, in other cases, with the living tumor cells, into the other individual and there produced the new formation of tumors. It is very probable that it will be possible to determine experimentally which of these two alternatives is correct, and thus arrive at a definite conclusion of the problem which we are seeking to solve. This will be the last link in the chain of factors determining the origin of cancer.

It is therefore not justifiable to state, as has been constantly affirmed only a few years ago, that the cause of cancer is unknown to us. In fact, we do know perhaps the principal factors with the result that in animals at least we can decrease or increase at will the cancer rate of certain strains by regulating the factors which we have analyzed so far. The next step will be to determine whether extremely small organisms or chemical substances are present in addition to the known factors. But even if we should have answered this last question, new problems will arise as to the manner in which chemical agencies (through which probably also microorganisms would ultimately act on the cells) can cause cell proliferation. And with this problem cancer research will

have reached common ground with general biology. The question of why certain stimuli cause certain cells to grow is one of the most important and far-reaching problems of general biology, since it is fundamental for both plant and animal life.

Equally important from the general biological point of view is the question of how heredity can determine whether or not certain external agencies will be more or less effective in changing the growth processes of a certain organism. But here also the problems of the origin and growth of cancer are in closest relation with other problems of biology.

To recapitulate then briefly what we know about the causes of cancer, we may make the following statment. We know the principal internal and external factors which cause cancer. We can experimentally modify or manipulate the internal and external factors in such a way as to change profoundly the cancer incidence in certain animals. By making appropriate matings between families of mice we can at will produce strains rich in cancers and strains poor in cancer. By changing internal secretions we can in certain strains of mice reduce the cancer rate from as much as 60 or 70 per cent. to nine per cent., provided the experimental interference is carried out at an early period in life. The problem which is not yet definitely solved concerns the manner in which those external and internal factors combine to cause cancer. We saw that there are two possibilities: It is possible that these factors cause a transformation of one cell equilibrium into another—the cancer equilibrium—and this would in the main differ from the cell equilibrium of ordinary life in the new production or in the greater production within the cells of the specific substance which causes abnormal growth. The same substance which would be newly produced in cells in the new equilibrium would also if injected into other animals of the same species, cause the transition of a cell from normal to cancerous equilibrium. In other words, through injection of those substances it is possible to produce a new cancer experimentally.

The second possibility is as follows: The external and internal factors which we mentioned make it possible for microorganisms to enter the tissues and to cause a transformation into cancer, or else they make it possible for a microorganism that has entered the tissues to initiate cancer growth. We are justified in believing that it will in the future be possible to decide between these two alternatives and thus to complete the solution of the problem.

Let us now turn to another phase of the cancer problem and try to answer the question, "Does the body that is invaded by cancer cells react against the cancerous growth; are in other words any mechanisms of defense apparent in the animal in which cancer is growing?" Before answering this question we must emphasize the very great distinction which exists between the spontaneous cancer, which has so far

been our main consideration, and the experimental cancer. In the latter we have to deal in almost all cases with a transfer of cancerous cells from one animal to another, while in the spontaneous cancer some of the cells of the animal itself become cancerous. In experimental cancer, then, usually cells of another animal grow within the inoculated individual. This distinction is of great importance when we come to consider the defensive mechanisms that arise within the body of the animal against the inroads of the cancer cells. We may briefly point out that spontaneous defensive mechanisms arise only in the case of experimental tumors (experimental tumors are foreign cells introduced into another organism and growing there), the body does not react defensively against spontaneous tumors. It is important to note that the defensive mechanism provided by the body against the attack of cancer cells can be artificially increased. This ability to bring into action defensive mechanisms we call immunity. The immunity produced in the case of experimental tumors, is, under ordinary conditions, not an immunity directed against the causative agent of the tumor associated with the cells and being either, as we have seen, a certain chemical body or a microorganism, but against the transplanted cells. Usually no immunity can be produced in the organism in which the cells have originated. But immunity can be produced against cells that are foreign to the organism—transplanted into it. The phenomena with which we deal in the process of tumor immunity are therefore not peculiar to tumors, but are the same in every case of transplantation of tissues. No defensive mechanism is developed in the individual against the cells of his own body, only against foreign cells. Thus if we excise a bit of skin or of the thyroid gland or of the uterus and place it in a pocket under the skin, the tissue remains preserved almost intact for a long period, probably during the entire lifetime of the individual. But if, on the other hand, we transplant a piece of skin from another individual of the same species, we find that the tissue is, after a longer or shorter period, destroyed within the new host. If we make careful microscopic examinations of tissue transplanted into a new host, we find that certain cells which circulate in the blood and lymph emigrate from the vascular channels of the organism in order to invade and gradually destroy the transplanted tissue. Other cells of the host also exert a deleterious effect on the foreign tissue and contribute to its final destruction.

If, instead of transplanting tissue from one individual to another of the same species, we inoculate an individual of a different species the tissue usually perishes directly through the influence of the body fluids which are poisonous for the transplanted tissue.

How can we explain these facts? We must assume that every individual of a certain species differs in a definite chemical way from every

other of that species, and that in its chemical constitution an animal of one species differs still more from an animal of another. Every cell of the body has a chemical character in common with every other cell of that body and also in common with the body fluids; and this particular chemical group differs from that of every other individual of the species and to a still greater degree from that of any individual of another group or species. Thus it happens that cells belonging to the same organism are adapted to all the other cells of that organism and also to the body fluids, but when transplanted into another organism, that specific substance which is peculiar to the individual is more or less toxic, or poisonous, for the new host, and causes the latter to react defensively against it by producing new substances which appear in the circulation and change the transplanted tissue. The transplanted tissue thus modified seems to exert an attraction for certain cells of the new host which hasten to the place in order to attack it. Or perhaps the transplanted tissue is directly altered by the foreign-body fluids and as a result defensive cells of the host are called into action.

Conditions are very similar when we deal with tumors instead of with normal tissue. Tumors which originate spontaneously in a certain individual can usually be transplanted without difficulty into another place in that individual. The cells remain alive and continue to multiply at the new place; but cells of a tumor when transplanted into another individual of the same or different species are destroyed, just as we saw was the case with the normal tissue. At this point, however, there is a difference between normal and cancerous tissue. While normal tissue in all cases is destroyed sooner or later after transplantation into another individual, there are *certain* tumors which in contradistinction to the large majority of tumors will grow in another individual of the same species after transplantation and sometimes even in an individual of a nearly related species. While structurally these *transplantable* tumors behave like other tumors, they differ from the large majority and from normal tissue in that they show a decreasing sensitiveness to the toxic action of those substances which differentiate one individual from another. These are the tumors which are used for experimental purposes. But, while it is true that these tumors will grow in a new host, it is not true that the cells of the new host are in all cases chemically like those of the tumor. Indeed, there is a difference which again makes it possible for the host to call into action certain defensive mechanisms against the invader, but these, under ordinary circumstances, are not strong or active enough to defeat it. There are, however, conditions which make the defensive action of the new host victorious over the inoculated tumor, and then it is destroyed. It is possible experimentally to increase the production of these defensive mechanisms.

There are certain tumors which grow in a new host of the same species for some time until, as a result of this growth, certain substances are produced by the host which cause the tumor first to stop growing and later to retrogress, become smaller, and finally to disappear. Other tumors may grow continuously without disappearing if transplanted into related strains of the same species. But if they are transplanted into different strains then they either can not grow at all or after temporary growth begin to get smaller and disappear. Thus it has been possible to demonstrate by experimental methods that there are fine chemical differences not only between different species and between different individuals of the same species, but also between different sets of families which constitute a strain, for certain chemical characters differentiate them from other strains of the same species. It has been shown, for instance, that white mice bred in Europe differ chemically from white mice bred in America, although the appearance of both strains may be identical. If we transplant an inoculable tumor of an American white mouse into a European strain, we find that such a tumor does not grow or that after a period of growth it becomes smaller, while in the American mice it does grow.

That certain chemical substances may become active to protect the new host against a transplanted tumor even if it does grow continuously can be shown by means of a second inoculation of the same kind of tumor and the same individual. We usually find that the growth of the first tumor has some inhibiting effect on the growth of the second tumor, but this inhibiting effect differs with different tumors. We must therefore assume that different tumors after transplantation into other animals of the same species contain a substance which characterizes the individual from which the tumor cells are derived more or less in the same way as the normal cells of an individual do, and that this differential substance calls forth protective mechanisms on the part of the host. Some tumors possess this differential substance to a lesser degree than others, or they are less sensitive to the defensive mechanism which is called forth in the host and they can therefore be more readily transplanted into other individuals.

As we stated before, it is possible to increase artificially the extent of this defensive reaction on the part of the host. We can accomplish this in a way similar to the one we used in the case of inoculation of bacteria. If we wish to produce a substance which is protective against a certain bacterium, we inject small quantities of dead bacterial substances or of the living bacteria after their virulence has been decreased, into the animal. Under the influence of these *vaccines,* as they are called, a certain immunity is frequently produced in the individual. If later we inject the fully virulent organism into the animal, it is often able to withstand the infection to which an animal not so treated would succumb. Now in the case of cancer the hostile agents

against which we have to protect the animal are the cancer cells taken from another individual which grow in the new host. If, instead of inoculating bacteria we inoculate normal tissue cells from another individual of the same species or tumor cells which happen not to grow in the inoculated animal, we find that after a certain time a kind of immunity is produced in that animal. If later we inoculate that animal with fully virulent tumor cells, this tumor very frequently does not grow. As we stated before, the majority of spontaneous tumors can not very well be transplanted. It is therefore comparatively easy to find a tumor which does not grow after inoculation, but which, nevertheless, forms a protective substance fatal to the growth of a virulent tumor. Now, while it is frequently possible to immunize against bacteria with dead bacteria or with certain extracts of bacteria, this is not possible in cancer immunization. Here we have to inoculate with living cells which only gradually die if transferred into the new host. Apparently a certain product of metabolism of the introduced cells, perhaps some product of oxidation, is necessary for this purpose, and such an oxidative process seems to take place only in the living cell.

How can we then interpret the mechanism which leads to the setting at work of these protective agencies? The most probable explanation is as follows: If the cell from the same species, but containing a differential chemical substance, is introduced into another individual, it attracts either directly certain wandering cells of the blood, which invade the tumor and also cause the connective tissue cells to form denser fibrous bands around the tumor, thus cutting off the nourishment from the transplanted cells, or such an effect is produced in an indirect manner. The differential chemical substance in the cells calls forth the new production of a chemical immunizing substance which circulates in the blood, or calls into action a substance which was already preformed in an animal and which it was not necessary to produce artificially. But even in the latter case an additional new formation of such an immunizing substance is added to the first substance which was preformed; these substances act upon the introduced cells, change their metabolism in a more or less injurious manner and call forth the reaction on the part of the wandering cells of the blood and of the connective tissue cells. We find, therefore, that in the case of tumors the reaction is exactly the same as with the transplanted normal tissue.

As stated before, after the so-called homoiotransplantation of tissue —a transplantation into another individual of the same species—certain wandering cells of the blood as well as the connective tissue are the principal agents in destroying the invading tissue. But just as in the case of auto-transplantation of normal tissue—a transplantation into the same individual in which it originated—no antagonistic reaction is called forth on the part of the wandering cells and connective

tissue, and no defensive reaction takes place, no chemically immunizing substance is formed against a spontaneous, autochthonous tumor. We find, therefore, that, after transplantation into another individual, cancers not rarely retrogress spontaneously. But such retrogression hardly ever occurs in a spontaneous tumor within the individual that produced it. And, moreover, not only does such a spontaneous retrogression not usually occur in spontaneous cancers, but we usually are not even able to produce experimentally a defensive mechanism such as appears when a transplantation occurs into another animal of the same species. Vaccination with either normal tissue or with tumor tissue that does not grow is of little or no avail for restricting the growth of spontaneous tumors.

We have now discussed the origin of tumors and the protective reaction in the body against tumor growth. There remains the third field upon which cancer research has shed new light. I refer to the character, conditions of growth and life of tumor cells in particular and of normal body cells in general. As has already been stated, the continuous transplantation of tumors has made very evident one fact of great biological significance, namely, the potential immortality of ordinary body cells. It had been assumed formerly that unicellular organisms like protozoa and bacteria as well as the *germ* cells—especially the ova of metazoa including the vertebrates—are potentially immortal. Provided no accident takes place, one protozoon can give origin to an endless chain of new individuals of the same species. In a similar way the germ cells of a multicellular organism, for instance, of a vertebrate, develop after fertilization into adult organisms; certain cells, however, fail to undergo the differentiation which other cells do and they form later on the germ cell—the ovum or sperm cells—in the new individual. Through fertilization they again are preserved and again give rise to a new generation of germ cells. In this way germ cells are potentially immortal, while all the other cells of the body, which, in contradistinction to germ cells, are called somatic cells, die with the individual. Now it was supposed that the death of the somatic cells was not an accident, but a necessary event distinguishing somatic cells from germ cells. This view cancer research has shown to be incorrect. We now know that most of the cells of the body are potentially tumor cells and we also know that tumor cells are potentially immortal, in the same sense as protozoa and germ cells. When we speak of "*immortality*" we must of course take into consideration the fact that periods of time which man can observe are always finite quantities and that to use the term immortality is to deal with only approximations. If then somatic cells usually die, it is due to a more or less unfavorable environment, conditions which we can not control at the present time.

There are some other interesting conclusions regarding cell life, to which cancer research has led. We have shown that it is possible

to increase and to decrease the growth energy of tumor cells at will by artificial means. If we expose tumor cells in test tubes to certain degrees of heat or cold before inoculating them into the new host, or if they are subjected to the action of certain injurious chemicals which are not sufficiently strong to kill the tumor cells, we find that the subsequent tumor growth following inoculation is very much impaired and weakened. These procedures, therefore, interfere with the action of those mechanisms which are responsible for cell multiplication. On the other hand, it is almost invariably possible to increase the virulence of tumor cells by subjecting them to mechanical stimuli, such as cutting into the tumor. Thus it comes about that tumors which recur after incomplete extirpation usually grow more rapidly than the original tumor. These observations make it very probable that the growth energy of somatic cells in general can be increased and decreased in a similar way and that the increase in growth energy in cancer cells is similar to that observed in normal cells in case of wound healing. In both cases mechanical stimuli increase growth energy.

There is a third class of observations of great biological interest that concerns the transmission of changes produced in one cell generation to another which itself has not been exposed to these changes. Thus it has been found that it is possible through the action of certain chemical substances which, for instance, may be injected into a vein and which reach the tumor only through the circulation, to produce a remarkably inhibiting effect on the growth of the transplanted tumor and in some cases even to cause its retrogression and disappearance. But we also found that through such injections the tumor cells become immunized against the action of these substances, that the effect, therefore at present is only a temporary one, and that this immunity is transferred to the next cell generation which had not been exposed to the action of the chemical. Thus in the case of somatic cells, as in the case of protozoa and bacteria, changes produced by external agencies may be transferred to at least a certain number of the following cell generations. And the same seems to take place in the case of germ cells—as in the effect of alcohol for instance—an effect transmitted to cell generations not directly exposed to the action of the poison.

If we survey what we have said of the methods and results of cancer research, one conclusion especially impresses itself upon us, namely, that there is a very close connection between cancer research and general biology. In cancer research, whether we deal with the origin of cancer, the reaction of the body against it, or the conditions favorable to its growth, we have to do in each case with the properties of cells, and these properties as seen in the cancer cell can not be understood without a constant reference to the normal cells from which it was derived. And conversely, our knowledge of the life of the normal cell,

which is essentially the problem of general biology, is broadened and deepened through cancer research. Cancer research is, in fact, a department of comparative general biology, and its fate is closely bound up with that of other biological sciences.

In closing I shall say a few words in regard to the practical application of cancer research—the prevention and treatment of the disease. We have found that there are internal and external factors concerned in the origin of cancer. Of the internal factors, heredity and the presence of certain malformations play a very prominent part in the development of cancer, unquestionably in animals and probably also in man. Of the external factors long-continued stimulation, long-continued irritation, of tissues is one of the important causative conditions. If we wish to prevent cancer we must be able to control all these factors. It is comparatively easy to do this in the case of external factors. Long-continued irritation of any sort must be avoided. Under certain conditions, for instance, it might be wise to remove all pigmented moles which are exposed to irritation. The control of the factor of heredity is more difficult. It would be one of the problems of eugenics. The difficulty, however, in applying theoretical knowledge in this field is two-fold: in the first place, living organisms are a great complex of hereditary unit factors, which are transferred from generation to generation independently of one another. This makes a selective mating very difficult. Advantageous factors are combined in the same organism with inferior ones, and it is at present almost impossible—at least in most cases—to determine which factors merit greater consideration, especially when we consider that the large majority of hereditary unit factors in the case of the higher organisms are almost unknown to us. The second difficulty in practical eugenics is the danger that methods which might be suggested for certain purposes would be contrary to that social understanding and sympathy which is the basal factor of our civilization. All we can say at present is that it might be advisable to avoid interbreeding between strains in both of which the tendency to cancer is dominant. But in the case of man even this conclusion can, at the present time, be drawn in only a tentative way.

As to the treatment: Science shows us that cancer starts as a local disturbance, and, from what we have learned, it follows that the earlier the local growth is completely eradicated the better will be the results. For this eradication surgical means should be employed in the large majority of cases. In a few selected cases some other methods might be indicated. Certain methods, depending on the application of different principles, are at present still of an entirely experimental character. How far it will be possible to develop them in the future we are not able to foretell. The investigator must follow his path quietly, guided by purely scientific aims. This will be the surest method of bringing about the greatest practical results.

INSECT MIGRATIONS AS RELATED TO THOSE OF BIRDS

By HOWARD J. SHANNON

JAMAICA, N. Y.

MOST of us know that many great flight-ways of migratory birds have been accurately mapped out both on the European continent and on our own. But no systematic attempt has ever been made to determine the flight-lines of migratory insects. In fact, it has hardly been suggested that such lines of travel exist. Significant movements, however, observed by the writer while stationed upon the southern Long Island coast seemed to indicate that both "monarch" butterflies as well as certain dragonflies habitually travel westward along that shore, and for many autumnal days in succession, in an apparent attempt to reach the mainland and an overland southward route to the tropic zone. These studies then not only suggested the theory that *both* insects were true seasonal migrants like birds, but also that similar avenues of travel must exist in other parts of the country. This conclusion has been strikingly upheld by further explorations. For, from additional evidence gathered in the field and by means of an extensive correspondence, it now becomes possible to define some of the principal insect highways of eastern North America. These should become the basis for the study of what is virtually a new science—the bionomics of seasonal insect migrations.

One such route evidently extends along the eastern coast from the far Canadian territory to the Gulf States. For, although the Maine-coast record of a "monarch" flight is the most northerly that has been reported, many of these migrants must be directed to these natural highways soon after leaving their summer habitat in the farther north. Both this record and most others reported along the seaboard are described as "butterfly processions" faithfully following the trend of the shore whatever its local direction. For they even turn westward along the Connecticut shore of the Sound (as recently observed by the writer), and beautifully parallel their similar coastwise behavior on the southern Long Island ocean coast.

In both cases, of course, they are bound for New Jersey; and thence continue southward until the waters of Chesapeake Bay seem to cause a partial, sidewise diversion. For a great swarm, moving at a considerable elevation, was seen in the year 1886, flying southward near the headwaters at West River, Maryland, which is situated far

inland. Other scattered flights have been seen in the streets of Washington. But whether these are all isolated occurrence or bands moving from the interior remains to be discovered. However, the great "resting swarms" reported at Charleston Harbor, South Carolina, show that many of the insects either preserve, or else recover, their coastwise habit, and persist in this extensive, continental flightway,

CANADA
MONTREAL AUG. 23 1880
DETROIT AUG. 7, 1888
BATTLE LAKE, LATE AUGUST 1888
MINNEAPOLIS SEVERAL YEARS
GREEN LAKE LATE AUGUST
SHEBOYGAN SEPT. 1870 MANY YEARS
RACINE SEPT. 1868
CHICAGO SEPT. 11
MILLERSVILLE SEPT. 9, 1905
ST. JOSEPH SEPT. 9, 1868
FAIRBURY AUG. 5, 1901
FAIR BURY SEPT. 7, 1879
MANHATTAN SEPT. 27, 1870
LAWRENCE MID-SEPT. 1906-1909
GIRARD SEPT. 17, 1877
ORLA-HOMA OCT. 5-8 1893
DENTON CO. OCT. 15, 1868
ALTON OCT. 31, 1870
WT. NEBO LATE AUG. TO LATE SEPT. 1893, 94, 95, 96, 97, 98, 1901 AND LATE AUG. 1913
TIPPECANOE COURT HOUSE SEPT. 12, 1890
SELMA LATE AUG. 1909
MACON SEPT. OCT. 6 NOV. 1870
APALACHICOLA WINTER 1879
TORONTO 1861
WEST POINT AUG. 15, 1794
PORT STANLEY SEPT. 1871
AMHERST BURG 1868
PRINT PELEE SEPT. 1903, 1906, 1907
HOPPES-TON SEPT. 10, 1905
OSSAWA SEPT. 10 1905
MIDDLETON LATE FALL 1909
GREENSBORO LATE AUG. 1914
TIPPETT-SVILLE SEPT. 1849
CIRCLEVILLE OCT. 4, 1907
WEST RIVER MARYLAND SEPT. 22, 1884
CLEVELAND MONARCH SWARMS SEE IN THIS REGION.
HAMPTON BEACH SEPT. 5, 1868
MAGNOLIA BEACH AUG. 23, 1888
MILFORD BEACH SEPT. 17, 1913
GUILFORD SEPT. 22, 23 24 1898
WESTHAMPTON MID-SEPT. MANY YEARS
LONG BEACH MID-AUGUST TO LATE SEPT. 1908-1913, FOR MONARCHS, 1914 & 1913 FOR DRAGON-FLIES
BRIGANTINE BEACH EARLY SEPT 1903
BRIGANTINE BEACH SEPT. 1883
ATLANTIC CITY MID-OCTOBER 1913
CAPE MAY SEPT. 27 1913
CAPE MAY SEPT. 5 1911
CHARLESTON HARBOR OCT. 8-9, 1913
CHARLESTON HARBOR AUG. 1872
ATLANTIC OCEAN
RESTING SWARMS OF "MONARCHS" (ANOSIA PLEXIPPUS).
FLIGHTS OF
RESTING SWARMS OF DRAGONFLIES
FLIGHTS OF
FLIGHTS OF GREAT SULPHUR BUTTERFLIES (CATOPSILIA EUBULE)
PROBABLE ROUTES OF "MONARCHS."

FIG. 1. AUTUMN INSECT ROUTES TO THE SOUTH. At least four great flightways are defined, (1) by the Atlantic Coast, (2) and (3) by the Great Lakes, and (4) by the West Central States. The great sulphurs inland flights in the South seem to move on a broader front except in the Ozark Mountains. (Map from the U. S. Geological Survey.)

whose further course, or possible termination, remains to be defined.

Farther west, along the northern shores of Lake Ontario and Lake Erie, another great route must exist, *even though no flights have been reported as moving in that general direction.* This flight-line was first suggested by reason of the steady, uninterrupted streams of "monarchs" reported by the bird student, Taverner, as coming down from the north, and then flying along Point Pelée, a peninsula jutting south-

ward from the northern shore of western Lake Erie. For they predicated some great, and probably specific, source of supply in the Canadian region. As a matter of fact, the territory immediately to the north was first considered the probable source of this living butterfly stream. But few, if any, records could be found in that region. What previous trail then could these myriads have followed other than the northern shores of the Lakes, as these were perfectly natural lanes of travel if the behavior already observed in the east could be duplicated here? For it would seem that, in this region too, most of the butterflies coming down from northeastern Canada would be held back and deflected by these water barriers, just as they are in Connecticut and Long Island by the Sound and ocean shore.

Only the evidence then was needed. This was readily supplied by reports of *resting swarms* at Port Stanley, Toronto, Montreal (for the route may even extend along the St. Lawrence Valley), and by the interesting description of "thousands, even hundreds of thousands of the red-winged butterflies *resting* on the shores of Lake Ontario at West Point," which was communicated to the writer by Miss Esther Steele, of Pittsford, N. Y. Moreover, this same observer reports that the butterflies never appear in any great numbers in this home region, almost directly opposite West Point, but near the southern shore, indicating that the insects rarely, if ever, cross the lake. This supposition is even further confirmed by another observer who *did* see a swarm at Cleveland, on the southern shore of Lake Erie; but who supplements his record with the statement, "they are seldom seen in this locality." Evidently, then, the "monarchs" usually avoid these great water barriers, preferring to traverse the 500 mile route already outlined, only to flood southward in the released stream which finds its outlet along Point Pelée and the contiguous islands leading to the Ohio shore, thence the flights probably continue directly southward, as shown by the record at Circleville; but after that point is reached our knowledge of their further course is lost.

Still another great route has been indicated along the west shore of Lake Michigan by reason of the swarms reported at Racine and Chicago. This flight-line, also, probably represents a released stream whose source lies still further north in some undetermined region beyond the Great Lakes. Its outlet toward the south, however, is shown by numerous reports throughout central and eastern Illinois, and, probably, by the flight still farther down country at Alton, where this tenuous thread, linking the insects of the temperate and the tropic zones, is lost.

But the wide highways of the Great Plains and the West Central States offer the most frequent reports of remarkable butterfly spectacles. In fact, they are so common in Minnesota, Iowa, Kansas, Oklahoma

and eastern Texas that they probably represent a mingling of various streams from Manitoba, the farther Canadian territory, and even from the northern shores of Lake Superior where a flight-line probably trends west only to turn south after passing the lake's extremity. The result is shown in gatherings of almost unbelievable magnitude. For here, unobstructed by barriers of lake, or ocean or mountain height, such as in other regions deflect and crowd the travelers into single-file processions, the mingled myriads move forward in broader, freer swarms that mount high, forming veritable crimson clouds; and in these impressive congregations—miles in width and streaming backward for equal distances—the crowding, ever-fluttering wings press onward toward the south, casting below them as they go perceptible shadows that move in company with the brilliant travelers in flight above the sunlit plains.

Vast aerial armies of dragonflies also advance along certain of the

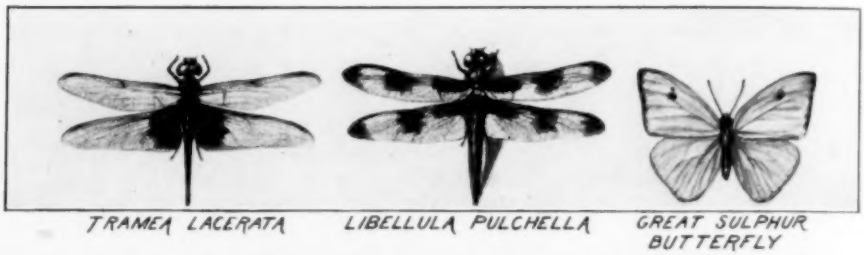

FIG. 2. SOME LITTLE KNOWN MIGRANTS OF NORTH AMERICA. These two interesting dragonflies have never before been reported in migration. The great sulphur, being a Southern butterfly, does not often reach the latitude of New York in any great numbers.

highways, although the scattered and broken processions are the usual mode of travel. Moreover, by using the routes already determined as a key, further confirmations are obtained regarding the seasonal character of their migrations in the manner of birds. For not only does the common Long Island migrant, *Anax junius,* travel southward along the Jersey shore, as shown by Wolff's September observation at Cape May, but also this same species travels westward along the Connecticut shore of the Sound as shown by the writer's August and September observations.

Then, too, a report of *resting swarms,* appearing at Point Pelée (the butterfly route already defined), would seem to show that *Anax* also follows our second great highway along Lakes Erie and Ontario. In fact, still further observations by the same observer, Mr. F. M. Root, show that eight other kinds of dragons, as well, appear at the point in late summer; and, as some species are less profuse in the earlier season, they are apparently migrating to another region. Among them are

the beautiful *Libellula pulchella* and the uncommon *Tramea lacerata*. And, as both of these species (as well as *Libellula semifasciata*) have been seen by the writer in extensive autumnal migration on Long Island, it is possible that both of these species, as well, follow the two great eastern routes already defined for the "monarchs."

Indeed, when we realize that great swarms of still another species, *Æschna eremita*, have been seen in annual, September flights at Sheboygan, which is on our third great route along the shore of Lake Michigan; and that the only other autumnal migration reported in detail in this country, that of *Epiæschna heros*, took place at Fairbury, Illinois, which is the direct continuation of the same route, one discovers a remarkably interesting coincidence. It is true that other flight-ways may be defined, and also that a more or less individual wandering course may be followed down country by both insects; but it seems equally true that the great water-barriers of the ocean and the Lakes divert both migrants into the common and crowded paths already described.

Such a fundamental coincidence prepares one for further identities between these routes and the flight-lines of migratory birds. This is, indeed, the remarkably interesting fact. For not only does a great flight-way extend along the eastern coast and along Point Pelée, indicating a coincidence there, but studies at Toronto, by Fleming, suggest that a great east-and-west flight-way for birds may pass through that city, a possible parallel to our second *insect route* along the northern shores of Lake Erie and Lake Ontario.

Regarding the third route along the Michigan shore, as well as the fourth route through the West Central States, it may be said (and this statement also applies to the eastern flight-ways), that the stronger flying birds are not so easily diverted as the insects: their southward flight follows a broader, bolder course. So, although birds doubtless follow a migratory course in most, if not all, of the regions defined above, the presence of feathered travelers on the southern shores of Ontario, and thence down the Genesee Valley, as well as other records farther west, show that the higher flying birds are more independent of land-contours than the feebler insect. And, although the bird is locally diverted by food supplies, the greater numbers of the migrants seem less slavishly diverted by geographical features than the insects which, in many cases, assume a lower habit of flight.

Yet, whatever effect further data may have upon the theory of a *general* similarity of route, there is, in certain local cases, an actual identity or veritable coalescence of the vast stream of mingled life that deviously finds its flooding way to the South. For where certain physical features combine to form narrow contracted flight-ways many types of both creatures are often thrown into a common path which

affords a remarkable and convincing spectacle. Needless to say, it is along such crowded highways that further discoveries of the rarer migrants will be made.

Just such a channel is formed by Long Beach, Long Island, where it narrows between ocean and bay. For two irregular lines of dunes also traverse this land-lane, still further narrowing its course and producing a miniature valley along which both feathered and scale-winged migrants multitudinously stream. Swallows begin to sweep past even in mid-August; an occasional humming-bird (seldom noted in the literature of migration owing to the elusiveness of its long flight to Mexico) sometimes hurtles past like a shot released; the eye can hardly follow it. While the ever-present "monarchs" and the various kinds of

FIG. 3. A CONTRACTED BUT DIRECT FLIGHT-WAY. Where Long Beach narrows between ocean and bay two lines of dunes form a miniature valley. Through it both birds and insects fly side by side, "Monarchs" represented by circle-tipped arrows; dragonflies by lozenge-tipped arrows.

dragonflies conform to an aerial route along the north slopes of the seaward dunes, or in the valley, with a precision so exact that one may take his stand beforehand and find them passing directly overhead or even within reach of one's hand.

Upon broken, irregular coasts quite different behavior is seen: some insects follow one path, others another. So confused and peculiar do some of these flight-ways become, in fact, that they have led to some erroneous conclusions. Just such an instance seems revealed by a letter written in 1901 by Mr. Henry Bird, a resident of Rye on the north shore of Long Island Sound. In correspondence with a Canadian entomologist he says:

> I used to find time for a day's fishing now and then and in a row-boat would anchor a half-mile out from shore on some submerged reef. . . . And one is sure to be struck with the number of butterflies constantly coming from the Island [Long Island] to the main shore. We might expect the supply to be largest on the mainland, and that emigration would be going the other way, yet it is invariably as first stated. By far the largest number seen will be *Archippus* ("monarchs"), next *Papilios* (swallowtails), and *Colias philodice* (clouded sulphur). "Monarchs" seem on the wing continually during the last half of the season, and their flight over the Sound waters seems most methodical. But in this case—they are going north, mind—they fly singly.

The Canadian scientist, Mr. J. A. Moffat, then concludes the insects were gathering in the north preparatory to a southward migration.

So curious a happening seemed worthy of further investigation, particularly as insect migrations along the Sound shores had only been predicted by the writer and never definitely proved. So Milford Beach, several miles farther east than Rye, was chosen as the place of observation.

How curious was the phenomenon that presented itself almost immediately upon my arrival during a late August afternoon! For not only were "monarchs," swallowtail butterflies and dragonflies flying from over the water and toward the shore—that is, toward the northwest—but swallows, as well, were accompanying them. All alike continued inland and disappeared from sight beyond the houses and woods in that landward vicinity. So here, almost at once, was a repetition of the peculiar spectacle reported from the Rye shore fourteen years before. What is the solution?

Former Long Island studies, where swallow and insect routes coincide, gave the key to the mystery. For, upon looking far out over the water, it was seen that the swallows were traveling more nearly parallel to the shore, and seemed to be winging their way from some outjutting point of land farther east (rather than from Long Island), in an attempt to pass over the waters of the cove or bay. But on being driven southward by the brisk northwest wind they, as well as the insects, which had evidently set sail from a similar point, were forced to turn

north, directly in the face of the breeze, and to beat against it in order to reach the land at all.

Further September studies confirmed this solution. For each outjutting point of land to the east—Welch Point, Pond Point and the lesser projection of Meadow's End—sheltered its resting or hovering companies of "monarchs" and dragonflies. Each point, too, was the launching place for one or another of the insects, or of both; and, although some moved along the curve of shore, many took the more hazardous, but shorter, route over the water. Even Charles Island, midway between the two arms of the cove, held its resting migrants or

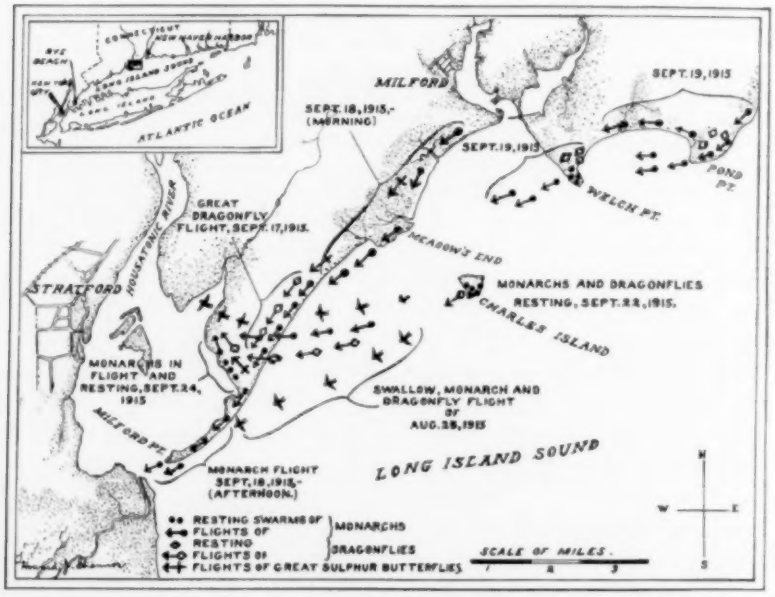

FIG. 4. CONFUSED FLIGHT-WAYS ON AN IRREGULAR COAST. On the Sound shore at Milford some insects and birds take short cuts over the water; others follow the trend of the shore. The curious northward movement around the east shore of the Housatonic is probably due to the food supplies found on that wooded shore. Occasionally both "Monarchs" and great sulphur butterflies are seen migrating southwestward through the streets of New York City.

its westward-flying units, which, owing to the small size of this land area, must have been bred upon the mainland.

The continued northward flight of both birds and insects, however, even after they have gained the Connecticut shore, seems to require a further explanation. This missing factor *may* be found in the mere presence of the Stratford marshes and the broad Housatonic waters which they border. For, although some migrants pass directly west over Milford Point, over these meadows and the Housatonic River, others (birds and insects alike) sweep northward to circle this sub-

merged area and only turn west, presumably, after passing around its perilous waters. Still the waters alone hardly seem sufficient to account for this northward diversion, as the greater reaches of the bay have been essayed without hesitation. Probably the true reason, then, is found, at least, in part, in the greater food supplies to be gathered along this wooded river-shore. For here the "monarchs" settle and feed; dragonflies hover in midair apparently gathering food, and even the swallows dip and glide as if refreshing themselves according to their usual habit.

This solution is further upheld by Dr. Bishop's careful studies in bird migration near New Haven Harbor, a quite similar body of water ten miles farther east. For here he saw repeatedly, not only swallows which are day migrants, but, also in the early morning, such nocturnal travelers as the bluebirds, robins, warblers, bobolinks and many others, nearly all of which were flying north or northwest along the eastern Harbor Shore. And, although he concludes that they were merely avoiding the wide waters, it seems more probable that they were hugging the land in order to feed after fasting through the long night journey on the wing. Moreover, so close is the parallel, in the writer's opinion, that further scrutiny should discover an insect route along this New Haven shore corresponding to our September flight-way by the Housatonic.

Still another butterfly migrant, the "great sulphur," often follows our Connecticut highways as well as the southern Eastern Shore. But this beautiful southern visitor is so fluctuant in its appearance and, at least beyond the forty-first parallel, is usually represented by so few individuals, that its summer sojourn passes almost unnoticed, and only the patient watcher of our autumn lanes of travel may catch brief, infrequent glimpses of its departing yellow wings.

In southern states it pursues regular, inland trails as well; for records recently communicated to the writer are so superior to any hitherto offered that they form a definite basis for further discovery. While resident at Mt. Nebo, Arkansas, my correspondent, Mrs. Jessie Rose Smith, was the interested observer of autumnal sulphur migrations toward the southeast for a period of ten years! It is true that the same observer has seen other southeastward flights in North Carolina and Alabama; still other students have reported similar movements in Alabama and Georgia as well. But they extend over a very brief period, and even another reference by Scudder, who quotes observations extending over a period of twenty-six years, is so vague in regard to place and direction that it has a secondary value.

But the Mt. Nebo flights, on account of the vast numbers involved, the constancy of their appearance ("we could predict their coming for days beforehand") and the uninterrupted sequence of the movements which began in late August and lasted for many weeks—

all these now familiar phenomena as observed in other insects—aroused the conviction that my correspondent must have been stationed upon some such crowded avenue of travel as has already been described in other parts of the country. Only a cursory glance at the relief map suffices to show the geographical features responsible for these recurring spectacles. For the Ozark Mountains, extending from the northeast to the southwest, lie at right angles to, and form a barrier across, the great sulphur's southeastward migration. So, held back by the hills, they are forced to turn aside and seek an egress to the warmer zone beyond these obstacles. But not until the gateway of the Arkansas Valley opens are the flocking multitudes able to move in the desired direction, and to stream past Mt. Nebo, which stands on the valley border, only to scatter again, no doubt, and move in more open order after passing the contracted flight-way of the hills.

PERHAM JUNE 5, 1888
FERGUS FALLS MAY 8, 1889
ST. ANTHONY PARK, MAY 28, 1888.
TORONTO MAY 10, 1906
LONDON JUNE 10,
BOSTON MAY 9, 1880
WEYMOUTH JUNE 3, 1920 DRAGONFLY FLIGHT
AMHERST MAY 13
JAMAICA, LONG ISLAND JUNE 14, 1915
STATEN ISLAND MAY 17, 1908
ANNESBURG LATE APRIL
LAKEHURST APR. 23
KEANSBURG MAY 15, 1915
VERMILION SPRING
NO MONARCHS (PROBABLY) SURVIVE THE WINTER IN THIS REGION
INDIANA
WEST VIRGINIA
VIGO COUNTY, MONARCH HIBERNATING IN WINTER
MACON MAR. 1879.
TORN OR WEATHERWORN SPECIMENS OF "MONARCHS"
CONDITION OF SPECIMENS NOT RECORDED.

FIG. 5. EARLY SPRING APPEARANCES OF "MONARCHS" IN THE NORTH. Their distribution shows that spring routes toward the North are probably somewhat similar to the flight-lines of autumn. It is significant that, in Europe, *both butterfly and dragonfly records of Spring* are the most profuse: here, the autumn flights are the greatest. (Map from the U. S. Geological Survey.)

Unmistakable as these mountain barriers are, however, both they and the lake and ocean obstacles, already noted, seem comparatively slight disturbances when one considers the general regularity of the north and south valleys and coast-lines in North America which are the natural lanes of travel. So, in this country, true insect migration, as well as that of birds, falls into comparatively simple, unobstructed channels. In Europe, on the contrary, the east-and-west position of the great mountain ranges, as well as the ever-varying direction of the coast-line, offer peculiar difficulties to the insect flights which, therefore, become deflected and confused. These conditions alone are sufficient to account for the great varieties of direction reported for dragonfly swarms on that continent. In fact, they may also account for the apparent failure of a true interpretation there; for only the study of our more direct, but corresponding, activities on this continent has seemed to throw a considerable light upon the problem. Butterfly migrations in the old world, too, have shown such varied behavior that the idea of regular seasonal movements rests upon far less definite data than has been obtained in this country. Nevertheless, as the writer has pointed out in a previous article,[1] the recorded instances of dragonfly migrations in Europe remarkably coincide with certain flight-ways of migratory birds; so there, as well, persistent scrutiny of certain continental highways should shed an additional light upon the other insect migrants that travel there.

The more they are studied the more impressive and thought-provoking do these parallel behaviors become, until one seeks to find some complementary light which may be shed by one creature on the activities of the other. For the hitherto almost unnoted spectacle of both life-orders flooding along the same great continental highways quite naturally gives rise to thought and conjecture. Indeed, it is not impossible that the insects, being perhaps the first historic travelers along the highways, attracted the insect-eating birds, resulting in an habitual adherence to those routes, where a constant food-supply could be secured during their long flight to the south. As a matter of fact an early report of a dragonfly swarm passing over Dresden states that "starlings, blackbirds and sparrows accompanied the insects and threw themselves upon them with great eagerness." Still, excepting for hawks, kingbirds, the purple martin and, to a lesser extent, the swallows, dragonflies are not habitually chosen for food. "Monarchs," moreover, are notoriously distasteful to birds. So, as regards these two insects at least, such a theory finds little support.

Nevertheless, there may be *even other forms of insect life* which habitually use the great highways—quite different insects which *would be* desirable for food. In the writer's opinion there are considerable

[1] "Do Insects Migrate Like Birds?" *Harpers Magazine*, Sept., 1915.

evidences to uphold this contention. A large bumble bee (or bee resembling fly as yet undetermined) has been seen driving steadily westward along both the Long Island and Connecticut highways, in each case flying side by side with the "monarchs." Along the Maine coast, too, according to a communication from Mr. Norton of the Portland Natural History Society, large bumble bees have been observed flying steadily westward across the water between the offshore islands and following the same general route which "monarchs" and birds pursue.

Certain small flies, *Ilythea*, have been reported by Scudder, migrating along the New Hampshire coast in the same general direction

FIG. 6. "MONARCHS" RESTING ON THEIR MIGRATION THROUGH KANSAS. This flash-light photograph, published through the courtesy of Miss Jennie Brooks, represents a part of the Lawrence swarm of 1909 described by her in Country Life for August, 1911. In 1906 larger swarms, also described by Miss Brooks in Harpers for June, 1907, rested for the night on the same tree.

already followed by a late summer "monarch" procession. The dragonfly swarms reported by Root on Point Pelée were preceded by large flocks of "deer flies" that seemed a part of the seasonal movement; while Eimer prefaces his description of a dragonfly flight in Switzerland by saying that swarms of the "flower flies" *Eristalis tenax* and *Syrphus lavandulæ* preceded the dragonflies, which were then upon a southward, September migration. So, as great numbers of *Eristalis tenax* have been seen resting along the Long Island highway where they are rare in the earlier season, further studies may establish a definite connection between these movements and the flights of certain insect-eating birds.

It is not impossible, in fact, that such a southward trend, or diminution of the smaller insects in the farther north, may take place in sufficient measure to account for the initial movements of the dragonflies. Certainly it does not seem true in this local region. For when the

FIG. 7. "MONARCHS" MIGRATING ALONG THE CONNECTICUT SHORE. They are setting sail from Welch Point and flying over the Sound waters in order to reach the next peninsula farther to the west. Charles Island, sometimes visited by the migrants, is visible in the distance.

dragons first begin to drift south along our highways in mid-August smaller insect life is still plentiful and widespread. But the same problem confronts us in the case of many birds which begin to arrive from the north before their insect food seems to show any noticeable diminution. Yet in this we may be deceived. Certainly the insect-eating swallows are among the first to start: on the other hand, the seed and berry eaters are among the last to leave. So, whatever results more exhaustive studies may show, the simultaneous early departure of dragonflies and the birds which also prey upon insect food is still another significant coincidence.

The laws, then, which govern the smaller, seasonal migrants seem so undoubted and severe that one can not fail to perceive that more complete and far-gathered data directed toward the problem of their beginning in season and in prehistoric time may even shed an additional light upon the very origin of bird movements. For, notwithstanding the voluminous literature which has grown up about the feathered migrants and the theories of climatic change initiated by the Ice Age as responsible for their annual flux and flow, these annual adventures still remain one of the most inexplicable and marvelous manifestations of animal life. It is equally true that the application of marking and tracing methods to insects (which have long been the practise of the bird student) will now be made possible, owing to the fact that certain of the eastern routes are clearly defined, allowing the naturalist to determine the extent of the southward movement in each species, the place and manner of the winter sojourn, and, also, how many of the northward-moving migrants of spring are new generations bred in that warmer region, and how many are, in very truth, the same individual travelers which set out upon their long, southward journey in the autumn.

SUBSTANCES WITHOUT CHEMISTRY

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SUBSTANCES without chemistry must necessarily be elements, for, if substances form compounds with other substances, they thereby come into the realm of chemistry. The group of elements to be considered are found in the atmosphere, but their presence was not suspected until less than twenty years ago, when within a comparatively short space of time, helium, neon, argon, krypton and xenon were discovered. Of these, xenon is present only to the extent of one part in 170,000,000 of air, but argon constitutes nearly one per cent. of the atmosphere. Yet, with the exception of the chemist Cavendish, no one seems to have suspected its presence and Cavendish merely suggests the existence of some unknown gas.

In this paper there will be several digressions that may seem foreign to the subject in hand, but that are intended to help in elucidating the main topic or to explain words or phrases necessarily employed.

Two classes of elements have eluded for a longer or shorter time the researches of chemists. One class is represented by fluorine. The story is told of a man who claimed to have discovered a universal solvent and, when asked to exhibit it, replied "How can I? It is impossible to get any dish to contain it." Fluorine is somewhat of this nature. The existence of the element was suspected. The mineral fluorspar was known to contain calcium, which is the metallic part of limestone, and was suspected of containing another element similar to chlorine, which is the non-metallic part of common salt. But this element could not be got from fluorspar in a manner analogous to that by which chlorine was obtained from common salt. The element could be detached from the calcium, but only to combine with something else. When common salt is acted on with concentrated sulphuric acid (the oil of vitriol of the newspaper reporter) hydrochloric acid, a very irritating gas, is produced, and this gas with suitable chemicals gives chlorine. When fluorspar is acted on with concentrated sulphuric acid a still more irritating gas, hydrofluoric acid, is produced. Its solution in water produces, on the flesh, very distressing sores exceedingly difficult to heal. Both the gas and its solution act on glass and the etching of glass is frequently done by the use of hydrofluoric acid. But hydrofluoric acid could not be made to act on any chemical in such a way as to set free fluorine. The element entered into innumerable combinations, but did not appear alone. Thus, though chemists had consid-

ered that there must be the element and had formed a pretty fair idea of what its appearance and properties would be, still, this element, that Davy in 1813 stated to exist in fluorspar, was not isolated till, in 1886, Moissan by the use of the electric current at a low temperature, with specially resistant apparatus, obtained the element in the form of a gas whose properties were almost identical with those predicted.

Another class of elements are elusive because their presence is not suspected, and their properties are somewhat similar to those of known elements. The metal cæsium belongs to this class. In 1846, Plattner analyzed the mineral *pollux,* but could not get the constituents as found by his analysis to add up to one hundred per cent. He published his figures, however. In 1860 Bunsen and Kirchhoff discovered the element cæsium, and it turned out that Plattner's analysis needed only the correction that the mineral pollux contained cæsium, instead of what he thought was potassium. The properties of potassium and cæsium are very similar; potassium is a common metal, while cæsium is not, and it was not till the delicate methods of the spectroscope were devised that any ready means of distinguishing between the two elements was available. The five elements discovered in the air are sufficiently similar to nitrogen as not to be distinguished from it until chemists had their attention turned to the matter by experiments undertaken with an entirely different object in view.

In 1785 the Honorable Henry Cavendish, of whom the Frenchman Biot in his obituary notice remarked that he was "the richest of all scientists, and the most scientific of all the rich," made some experiments with air by passing electric sparks through it, in this way producing nitric acid and potassium nitrate (saltpeter). It is notable that this process that Cavendish first applied on the small scale and with excessive toil is now carried out on the commercial scale in Norway and Sweden, where electric power is cheap. Up till three or four years ago, however, not more than one per cent. of the world's supply of nitric acid was made in this way, since, for the most part, it was cheaper to get it from sodium nitrate or Chili saltpeter, so named from its place of origin in South America. But as 50–80 per cent. of all the more important explosives consist of nitric acid and as Germany must be pretty well shut off from South America, she must either have laid in an enormous stock of nitric acid before the war or the electric process must have since been greatly developed, unless, indeed, she has gone back to the primitive method by which saltpeter is made in the villages of India, which is very unlikely.

When Cavendish passed electric sparks through air and oxygen added as required, he found that though the volume of air diminished until it became very small, it was impossible for him to reduce it to zero; a little gas remained. He had recognized the air as containing

the gases which we now call oxygen and nitrogen, and he said that if what remained behind was not nitrogen its volume was not more than one one hundred and twentieth that of the nitrogen. He did not carry his experiments any farther, a course of action not to be wondered at when we learn that he and his assistant in carrying the investigation to this point had already kept turning the handle of the frictional electric machine for the not inconsiderable period of three weeks. Most people would count that a long enough time to keep the nose to the grindstone.

It is now possible by simply switching on an electric current to obtain the same result in a much shorter time; but, although for the last fifty years or more Cavendish's experiment could have been repeated with ease, no one thought of attempting it; and text-books in chemistry continued calmly to assert that air consists on the average of 20.96 per cent. of oxygen and 79.04 per cent. of nitrogen.

Attention was drawn to the subject owing to an investigation carried on by Lord Rayleigh, with no thought of the wonderful outcome of his work, which was started for an entirely different purpose. He set out to determine the densities of various gases, in the first place the relative densities of oxygen and hydrogen, at which he worked from time to time during ten years 1882–1892. After that he determined the density of oxygen and nitrogen and of air with a view to determining the percentage of the two gases in the atmosphere. Lord Rayleigh prepared the gases in different ways. Oxygen was prepared in three different ways, but, no matter in what way it was prepared, its density was always the same. Such was not the case with nitrogen, however. Of the nitrogen obtained from five different chemical compounds which Lord Rayleigh employed, the amount contained in the globe that he used weighed on the average 2.29900 grams, while the nitrogen obtained in three ways from the air weighed on the average 2.31049 grams. Translated into English measures, this means that approximately three pints of nitrogen got from air weighed about one seventh of a grain more than the same volume of nitrogen from the chemical compounds.

The ratio between the two weights was not far different from that between an ordinary letter, before and after the stamp is put upon it; but the actual difference in weight was only about one tenth the weight of a postage stamp. But the greatest difference in the weight of the nitrogen obtained from the different chemical compounds was not more than one seventieth the weight of a stamp, while in most of the experiments the difference was much less. It was evident then that the difference noticed between atmospheric nitrogen and what might be called chemical nitrogen could not be due to Rayleigh's errors in weighing.

Rayleigh at first inclined to the opinion that atmospheric nitrogen

was the real nitrogen and that chemical nitrogen was lighter because of the presence of some lighter substance mixed with it, but this opinion was proved to be incorrect. Then it was suggested that possibly atmospheric nitrogen was heavier, because some of the molecules contained more atoms than real nitrogen. There is pretty good proof that the molecules of nitrogen consist of two atoms; the suggestion was that atmospheric nitrogen might contain a certain percentage of molecules consisting of three or four atoms. It has been long known that electric discharges through oxygen produce an effect of this kind. Part of the oxygen is converted into ozone, which is denser, so that the same volume would have greater weight. It was proved, however, that no similar phenomenon occurs with nitrogen.

At this stage Professor Ramsay joined forces with Lord Rayleigh and, by passing nitrogen obtained from air through a red-hot tube containing magnesium, he found that, though most of the gas combined with the magnesium, a small portion did not do so, though the process was continued for ten days. This small portion was about one eighty-fourth of the whole. When chemical nitrogen was subjected to the same treatment it was entirely absorbed.

Lord Rayleigh repeated under more favorable conditions and with larger quantities of air, Cavendish's experiment of passing sparks through a mixture of air and oxygen and got a gas identical with that obtained by Ramsay. This gas is heavier than nitrogen in the ratio of ten to seven. Many experiments have been tried, but without success, to make it combine with other substances. It is inert, hence the name argon from the Greek word with that meaning. It has no chemistry—all the experiments possible with it are physical. Its inertness kept it a long time undetected. Its inertness makes it of no chemical value now that it has been found, except in so far as its inertness may affect chemical theory. Ramsay, having found argon in the air looked about for some other source. While doing so he received a letter from Miers, the mineralogist, at that time connected with the British Museum, who suggested that it might be well to examine some uraninites (varieties of pitchblende largely uranium oxide). Hillebrand, one of America's most noted analysts, had obtained a gas from uraninite which he supposed to be nitrogen. Ramsay thought it improbable that Hillebrand's methods would prepare nitrogen from any of its compounds and he reexamined one of the minerals used by Hillebrand, namely, clèvite. He did *not* find argon, but he found a gas not previously discovered on the earth, though it had been found in the luminous atmosphere of the sun, by means of the spectroscope in 1868, or about twenty-six years previously.

It may be noted that the name *helium* had been given to this element not *helion*. Nearly all the metals except the very common ones

that have been known for centuries terminate in *-um* or *-ium*, for instance, platinum, aluminium, sodium, potassium. On the other hand, several of the non-metals terminate in *-on*, for example, carbon, boron, silicon and all of the elements except helium that are similar to argon. When helium was discovered in the sun, from which it got its name, there was nothing to show that it was not a metal, and, though the Green termination *-on* would have been more suitable, it is not likely to be adopted. At the present time, the spectroscope reveals in some nebulæ, an element not found on the earth as yet, and to it the name *nebulium* is given.

Hillebrand was unfortunate in not discovering helium. The gas that he obtained responded to the tests for nitrogen, though not so rapidly as he had reason to expect with pure nitrogen. He and his assistant jokingly suggested that they might have found a new element, but as they thought it unlikely they did not pursue the investigation and so helium remained undetected for five years longer. Ramsay showed that the gas from clèveite contained 12 per cent. of nitrogen. This Hillebrand detected, but not the far larger amount of helium.

Hillebrand is not the only chemist to make a similar error. A bottle containing a heavy reddish-brown liquid was sent to Liebig for analysis. He thought that it was chloride of iodine and did not investigate it very thoroughly. Some time afterwards, in 1826, Balard discovered bromine, and Liebig realized then that his specimen was bromine, and he gave it a place in his special cabinet for storing mistakes. He was accustomed to cite it as an example of how one may miss a great discovery.

Helium is found in a number of minerals, usually in cavities of microscopic size and under a pressure of several atmospheres. In several places in Kansas, natural gas has been obtained containing more than one per cent. of helium, while in a number of other localities natural gas contains a less proportion. It is also found in some mineral waters. Experiments, carried out by Rayleigh and Ramsay, seemed to indicate that helium does not exist in the air, and Dr. Johnston Stoney gave a mathematical proof that it could not permanently remain in the air, as it is so light that the earth's attraction would not be sufficient to retain it. Whether it is produced rapidly enough to keep up the supply or that there is some unknown factor not taken into account by Stoney, the fact is that helium has been found in the atmosphere to the extent of about one volume in 185,000. Helium is only about one seventh as heavy as air and so the proportion by weight is correspondingly less. It may be added that hydrogen is even lighter than helium and even hydrogen is found to the extent of one part or more in 100,000.

The liquefaction of helium is of interest, but before taking it up it will be well to sketch the history of the liquefaction of gases. In 1823 Faraday liquefied chlorine. Other gases were liquefied by him in the

same manner. But some gases resisted liquefaction by this means, conspicuously those existing in the atmosphere. These were called permanent gases. But in 1877, Pictet and Cailletet independently succeeded in obtaining a few drops of liquid air. In 1895, processes were invented by which air could be liquefied by the gallon. Hydrogen resisted liquefaction, till Dewar, in 1898, succeeded in reducing it also to the liquid form. There was left one gas only, namely helium, unliquefied. A sufficiently low temperature was not available. But in 1908 Omnes gained the distinction of liquefying this last remaining gas and obtained a liquid that boils at 4.5 Centigrade degrees above the absolute zero of temperature, but that, so far, has not been solidified, though a temperature as low as 2.5° absolute has been reached.

A word of explanation should perhaps be given as to what is meant by absolute temperature. The difference between our coldest winter weather and hottest summer is a little more than half the difference between freezing and boiling water, which on the Centigrade thermometer is one hundred degrees. The melting point of ice is zero on the Centigrade scale, the boiling point of water is 100° C. Bright red heat is about 1,000°; furnaces for iron is 1,300–1,700°; the melting point of tungsten is 3,000°; in the electric furnace a temperature of 3,500° C. has been reached, perhaps even a higher temperature. Probably no temperature higher than 4,000° C. has been made by man, but the temperature of the sun has been estimated at 6,000° C. There is nothing to prevent us conceiving of a temperature of 10,000° or even of 100,000° in the same sense as we can conceive one hundred million dollars. While, however, we have no difficulty in attaining a temperature of seven or eight hundred degrees and can attain a much higher temperature, we not only have not reached a temperature of three hundred degrees below zero, but we are almost certain that such a temperature is impossible. Several lines of argument lead to the conclusion that at —273° C. a body would be absolutely without heat and that any lower temperature is therefore impossible. So —273° C. is called the absolute zero and helium has been cooled to —270.5° C. or 2.5° absolute without having been frozen. The difference in temperature of a room very slightly chilly and almost comfortably warm is about 2.5°.

Liquid helium is about one seventh as dense as water, which is approximately the same ratio as the gas bears to air at the ordinary temperature. When boiling the volume of gaseous helium is only eleven times that of the liquid, while steam is nearly seventeen hundred times the volume of the water from which it is produced.

In 1898, Ramsay and Travers published accounts of three other gases found in the air, *krypton* and *xenon* being heavier than argon and *neon* being lighter. The two heavier ones were got from liquid air. Liquid air is produced on the commercial scale; one of its chief uses is

as a source of oxygen. Liquid air consists mainly, of course, of nitrogen and oxygen and when it boils nitrogen volatilizes more readily than oxygen, just as alcohol distils off from water with which it is mixed. So oxygen is left behind just as water is left behind, a somewhat bluish liquid with the peculiar property of being magnetic. After the nitrogen, the oxygen volatilizes and when it has nearly gone the small quantity of liquid left is mainly argon but there is a little krypton and xenon. Ramsay and Travers used about six gallons of liquid air, Moore some time afterwards made use of the residue of a quantity of liquid air which will by most people be considered really large, namely, one hundred and twenty tons. There is one part of krypton in twenty million parts of air by volume and one part of xenon in one hundred and seventy million parts of air. Thus 120 tons of air would yield between twenty-five and thirty cubic inches of xenon and about eight times as large a volume of krypton. The latter name refers to the gas being hidden by or in the large quantity of argon which it closely resembles. There is a rare metal *lanthanum* whose name has a similar origin, since the properties of its compounds are so similar to those of another metal that it escaped notice for a considerable length of time.

The *aurora borealis* has been the object of admiration and speculation for centuries. Cavendish, whose connection with the main subject of this paper was so conspicuous, calculated the height of the aurora to be from fifty-two to seventy-one miles and probably this calculation is not far wrong. One of the theories regarding the cause of the aurora is that it is due to electrical discharge through the rarefied atmosphere and De la Rive of Geneva made a model to represent the discharge influenced by a magnet in much the same way as terrestrial magnetism affects the aurora.

When the aurora was examined by the spectroscope a very intense green line, not known to belong to any element, was found. When Ramsay was working with krypton, his assistant, Baly, examined its spectrum and noticed among a number of other lines a brilliant green one whose wave-length he measured carefully. No sooner were his results published than letters were sent to Ramsay and to the scientific press pointing out that this wave-length corresponded to that of the most important line in the spectrum of the aurora.

Neon does not call for special comment. It is lighter than air and has a spectrum not already known, perhaps receiving its name of *new* from this fact. There is one part in about 55,000 of air.

All these elements are incapable of forming compounds; they are all inert; they have no chemistry. The atomic weight of most elements is arrived at from chemical considerations, the analyses of compounds, and such like experiments. The atomic weight of these elements can not be arrived at in this way. The density as compared with hydrogen can be determined, but this alone will not fix the atomic weight, the relative

weight of the atom compared with the atom of hydrogen. One of the most important means for arriving at the number of atoms in the molecule, and in that way the atomic weight, is by determining the velocity of sound in the gas. This velocity is found in a very ingenious manner in a quantity of gas contained in a glass tube a few feet long and a small fraction of an inch in diameter. The determination of the atomic weight of an element is one of the most important investigations connected with it and for these elements physical not chemical means must be used.

Belonging to the same group of elements is still another gas, *niton*, which is not found in measurable quantity in the air. It is given off by the element radium and is sometimes called radium emanation. That it is not found in the air is not to be wondered at, since if a quantity equal to that of argon in the atmosphere were suddenly introduced into the air, it would within three months diminish to less than the quantity of xenon changing from one part in a hundred to one part in two hundred million of air. This is because niton decomposes so rapidly. In less than four days any quantity will diminish to one half what it was at the beginning of the time. One of the products of decomposition is helium, another is a substance metallic in character which itself readily disintegrates. This substance deposits on a negatively charged body brought into contact with niton, and the fact that a negative wire in the atmosphere acquires such a deposit, which may be rubbed off or dissolved by ammonia, is taken as indication of the presence in the air of an infinitesimal quantity of niton. Any further discussion of this matter would lead too far afield.

The above are all the elements *known* to belong to this group; but the Russian chemist Mendelèef, whose arrangement of the elements according to their atomic weights in series and in groups was epoch-making in the science of chemistry, suggests that there may be two other elements in the group, elements very much lighter than hydrogen, one of them almost infinitely lighter. One is the corona of the sun, the other the luminiferous ether. At present we have no means of testing Mendelèef's hypothesis.

A GLANCE AT THE ZOOLOGY OF TO-DAY

By Professor H. V. WILSON

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WHEN zoology is mentioned, our first thoughts turn to the different kinds of animals, to the so-called species; to the birds and insects round our homes, to the fish we have caught; to the less familiar forms of the coast, the sponges, medusæ and corals; to the beasts we have seen in zoological gardens, to the specimens exhibited in museums. This richness in variety is pleasing to most of us, and it is small wonder that the work of collecting and describing has been so actively pursued. The forms of animal life sufficiently different to be enrolled as separate species now number about half a million.

Strange as it may seem, one still at intervals hears the question, "what is the use of all these creatures?" meaning their use to us, to man. Perhaps the question is never very seriously asked to-day. For we all know a long list of organisms who, if they bring us tribute, bring a strange kind. We think of that prince of evil, the tiger; of the cobra; of parasitic worms that bore through the living flesh; of bacilli that bring disease after disease; of protozoa that cause malaria and sleeping-sickness. And we recognize that the material world is not obviously anthropocentric.

Modified, however, the question is a very rational one: what forms are inimical to us, what forms directly or indirectly useful? This question, essentially economic and hygienic, tends greatly to increase our interest in natural history, in the knowledge of the kinds of animals, and the changes of form, habit and home which they undergo during individual life. We become aware how complex are the interdependencies of organisms, how interwoven are their life-histories. We find that it is largely on such knowledge that the medical scientist and the sanitary engineer draw when they seek to combat the infectious diseases, and how vitally helpful such knowledge is to the various branches of animal industry.

These considerations show us plainly enough that biology is useful, and in making this statement we perhaps express the real nature of our knowledge in general, as something not final and comprehensive, but detailed and practical. Let us, however, not confound this aspect of the nature of knowledge with the method of science. Because the world is so ordered, and its ways so interconnected, that any or all knowledge may after a time prove useful, is no reason why we should concentrate

our attention chiefly on tasks and problems that are of immediate practical importance. On the contrary, as we survey the history of science, we see clearly that inquiries into the causes or beginnings of things, irrespective of direct utility, are of the first importance. It is these which lead to the emergence of the great general ideas, which, in their turn, light the way to the discovery of special facts that are of direct utility.

Turning from the utilitarian aspect of biology, let us take up for a moment a problem which, never new, is yet always interesting. What is the origin of all these forms that we have learned to know? What is the nature and origin of species, or, choosing the phraseology of the day, of specific differences?

In the histories of the theory of evolution we read, wondering if any of our present-day notions shall prove as untenable, that Linnæus held that species were changeless, that they were in character and number precisely as originally created. We read that somewhat later, when fossils were better known, Cuvier interpreted the present organisms and the very different ones of past geological periods as the results of separate acts of creation, each period with its living things coming to an end in some tremendous catastrophe. And that still later Louis Agassiz held the same view, while meantime he with many others paved the way for evolution by discoveries of fact, bringing to light the existence of fossil series from low forms to high, and many illustrations of the generalization embodied in our "biogenetic law" of to-day, namely, the generalization that organisms do not pursue a straight path of development from egg to final form, but commonly develop temporary peculiarities of structure constituting resemblances to lower forms.

The strong tide of evolutionary doctrine that set in with the publication of Darwin's great book in 1859 brought nothing new to what had been taught by Louis Agassiz as regards the existence of the resemblances, just alluded to, between organisms, adult, embryonic and fossil. But that the stream of living matter has been continuous from generalized type to derived form, or, as we say, from ancestral type to descendant, this is the conception that rings out the note of difference from Agassiz's teaching. Basing its argument on minor mutability that can be demonstrated and on a mass of circumstantial evidence, overpowering in its cumulative effect, evolution claimed that fundamental resemblance is not a transcendental likeness, but is due to kinship. With this conclusion we are long familiar. It has entered into the very marrow of our mental life, and everything that we learn corroborates it. The conclusion concerns us in a direct way, for the evolutionary process can not be thought of as something finished and done with. Rather do we conclude that if organisms *have* changed, they are still changing.

Granted the fact that organisms change, the question veers and we

ask in response to what do they change? Are the changes natural phenomena throughout and, as such, due to natural causes, like the up and down heaving of the earth's crust?

We are confronted to-day, as in past times, with two interpretations of nature. On the one side argument, clad in the robe of philosophy, would lead us beyond the border of the phenomenal world, seeking a reality on which all phenomena are dependent. Many tell us there is such a reality—and certainly nothing that we know contradicts them. On the other hand, the obvious world is a world of natural phenomena, which, although at bottom incomprehensible, prove on study to be orderly and predictable. That is, we learn through experience that one occurrence is associated with another, that one change brings about the next, that for every effect there is a cause.

Returning to our question, it may be said that we work and work successfully on the theory that the changes which organisms undergo are natural phenomena brought about, like any others, by natural causes. The transformation of a horde of barbarians into a modern European nation; the immunity which a race acquires against specific disease; the evolution of new breeds of dogs, horses and wheat; the spreading of a race over a wide and varied area with the consequent appearance of differences which mark off the group into geographical subgroups; the gradual loss of parts of the body, so obvious in some fossil series; the metamorphosis of a part into what is virtually a new organ; the restriction of a species to a narrow area of distribution, with the final outcome, extinction; all these we are justified in regarding as natural phenomena and as phases in the wave of change that incessantly passes over living nature.

Granted the fact of change and that it is a natural phenomenon, we become interested in the analysis of its causes. And so we begin to inquire into the origin and accentuation of the small differences which mark off a race from the parent stock. Thus we pass from the wider study of evolution to the narrower and more precise study of heredity and variation. Here the experimental method is the chief one employed, although often under the guidance of comparison and statistics.

I pass over the ideas entertained as to ways in which differences are accentuated and touch, in preference, on some of the ways in which they originate. We know very well that the body of an animal, its skin, bones, muscles, etc., made up of infinite numbers of microscopic components, the cells, responds to changes in exercise, food and environment with the production of differences which are often very well marked. But we also know that the great bulk of the obvious and familiar differences so caused are not passed on to the next generation. They are not heritable. In order to be heritable, the peculiarity must be lodged, potentially, of course, in the germ cells. These are the cells,

commonly ovum and sperm, which, leading a life aloof from the body cells, give rise to the new individual.

We may then ask, do all individual differences that are heritable originate from the very start in the germ cells, and, if so, owing to what influences? or are there subtle changes of the body cells induced by habit, food and environment, which are transmitted to and lodged in some potential form, in the germ cells? This two-sided question, it is obvious, concerns mankind in a very practical way. It has been argued warmly for many years, usually under the heading of "the inheritance of acquired characters," and still to-day, in a more clearly circumscribed shape than formerly, makes one of the most important general problems of experimental biology.

In past years it was widely held that the transmission from body to germ was a fact, in other words, that peculiarities developing for the first time in the body, not as the result of congenital constitution, but as the result of habit or outward circumstance, were transmissible to the germ. Weismann and others have shown that much of the evidence on which this conclusion rested is weak, and the result of their criticism has been in some measure to discredit the idea. There are, nevertheless, certain experiments which, while not demonstrating transmission from body to germ, do demonstrate perhaps the more important fact that the effect on the body of outward circumstance in one generation may be in some degree repeated in the bodies of the next generation, although the conditions which first induced the change are no longer operative.

Prominent among such experiments are the classic investigations of Standfuss and Fischer on European butterflies. Both Standfuss and Fischer showed for certain species that the temperature at which the pupal stage is kept, during its so-called sleep, may be made to affect very seriously the coloration of the butterfly into which it metamorphoses. In this way by employing temperatures above the normal and temperatures below the normal, butterflies are obtained very different in appearance from the type.

Standfuss having in this way obtained strongly altered individuals, bred from them, keeping the butterflies and their offspring not at the abnormal temperature which induced the change, but at the normal temperature. The great bulk of the offspring, the second generation of butterflies, proved to adhere to the usual type of the species. Nevertheless, a few examples departed from the type and resembled in varying degrees their parents.

In a similar experiment, Fischer subjected pupæ to an intermittent cold of —8° C., and in this way obtained butterflies different from the type. The offspring of these modified individuals fell into two groups, those adhering to the type and those resembling in greater or less degree the modified parents. The percentage of the latter was a considerable one.

These and numerous other experiments (such as those of Schübeler on German wheat transplanted to Norway and back again, the work of Tower on the potato beetle, that of Sumner on breeding mice at low and high temperatures, etc.) unquestionably show that the environment can exert a modifying influence on the hereditary constitution of a race, that it can originate heritable differences between organisms. They show, moreover, that it sometimes happens that a definite change is made in the body and a corresponding change in the germ cells, the change in the body of the first generation, thus showing in a measure what the heritable effect on the race will be. These important experiments mark a real advance, and it is safe to predict that they are but the precursors of many more dealing with the effect of the environment on the germ cells. At present one can not but feel that the amount of evidence is too slim to decide the question as to whether the environment first produces an effect on the body which is then transmitted to the germ cells, or whether the environment acts directly upon the germ cells, producing in them potential changes parallel to those produced in the body.

A second way in which heritable differences between organisms originate, that is, a second way in which changes in the properties of the germ cells are induced, is through amphimixis or development from two parents, wherein two sets of hereditary tendencies are intermingled.

Adopting this general method, investigators have in recent years attacked the problems of heredity and variation from two sides. On the one hand, students of experimental embryology, cross-fertilizing the egg of one species with the sperm of another, have occupied themselves in tracing the influence of the respective parents as displayed in the growth and differentiation of the hybrid germ. Sea urchins, frogs, fish are the objects which more than others have been used for such studies. This is too technical a field to admit of brief description. If there were time it would be easy to show that the connections between the study of embryology and heredity are numerous, close, and indeed fundamental to any real understanding of either.

The other great application of the method of cross-breeding to the study of heredity concerns itself not with the gradual individual development but with the reappearance of the characteristics of adult organisms in the offspring and later descendants. In this study a remarkable activity now reigns, dating from the year 1900, when certain principles of hereditary transmission, originally discovered by Mendel and published in 1865 but subsequently lost sight of, were rediscovered by several European botanists. These principles lie at the center of that collection of data, law and explanatory hypothesis which we designate Mendelism and which is the outcome of a vast amount of experimental breeding of animals and plants of many kinds.

The fundamental principles of Mendelism are no doubt familiar to

many of you. In this study attention is concentrated not upon the influence which one parent as a whole exerts upon a descendant, but upon the transmission of particular characteristics. The characteristics to which attention is paid are those in which the two parents differ sharply. They are contrasting characters like blackness and whiteness of fur in the rabbit, tallness and dwarfness of the pea vine, roughness and smoothness of coat in the guinea pig.

The conclusion of fundamental importance is that such characters do not blend in the descendants, but are passed on from generation to generation in their original distinctness. The characters, Mendelian or unit-characters as they are called, may be obvious or latent. In the familiar case of rabbit breeding, when a black and a white rabbit are bred from, the offspring are all black, but whiteness is latent in some, for if the black offspring are interbred, a certain proportion of white rabbits will appear among the grandchildren.

A point of importance is that the Mendelian characters of an ancestor behave in heredity independently of one another in such wise that new combinations may be made. Thus, if a dark, smooth guinea pig be bred to a white rough guinea pig, and the offspring be interbred, the grandchildren will be of four kinds, with respect, that is, to the qualities darkness and whiteness, smoothness and roughness (W. E. Castle). Some will be like the grandfather and some like the grandmother. But there will be other grandchildren like neither of the grandparents. In these a grandfather feature is combined with a grandmother feature, and so we get dark rough and white smooth pigs.

Thus qualities which exist apart from one another in separate organisms may be combined in one and the same individual, and new breeds be created. In such new breeds it is apparent that new qualities are not created. What is created is a new combination. This is heritable and therefore marks off the breed from others. Hybridization here, then, originates heritable differences between organisms. It may be added that the independent behavior of Mendelian characters in heredity is not necessarily equal throughout a long series of characters. In other words, characters sometimes, perhaps always, tend to reappear in groups. This important fact has been especially brought out by recent work on the heredity of the little fruit-fly, *Drosophila* (T. H. Morgan).

In a loose and general way it has always been known that new combinations of characters occur in organisms bred from two parents. In this connection Goethe's verses have often been quoted by Haeckel and others:

> **From father I get my height**
> **And my earnestness;**
> **From mother dear my gladness of nature**
> **And delight in romancing.**[1]

[1] "Vom Vater hab' ich die Statur," etc.

But Mendel's achievement was to discover order where no order had been recognized, to demonstrate that the combinations which are made are of a constant character and, moreover, are embodied in groups of grandchildren numerically proportionate to one another. We have seen that where, as in the case of the guinea pigs, two pairs of characters are considered, there will be four kinds of grandchildren. It may be added that in such a case the four kinds will be represented by the proportional numbers 3, 3, 9, 1. That is, for three of one kind, there will be three of another, nine of another and one of yet another. The larger the number of contrasting points, the greater will be the number of kinds of grandchildren. Thus Correns, one of the rediscoverers of the Mendelian principles, calculates that if the first parents differ in respect to ten points there will be more than a thousand different kinds of grandchildren.

Mendel's explanation of the phenomena that now bear his name was in the shape of an hypothesis which with various alterations, some of which are important, is in general use to-day. He conceived of each contrasting character as potentially represented in a germ cell by a particular "something." This something we speak of as a germinal factor, a unit-factor or a gene. It is thought of as a definite entity. Many, indeed, perhaps most, look on it as a material particle. Others do not make the attempt to visualize it. When the egg and sperm fuse, corresponding germinal factors are brought together in pairs, each pair of factors representing a pair of contrasting characters, blackness and whiteness of rabbit fur, for example. Thus brought together in the fertilized egg, the two factors of a pair may each produce an effect on the body of the organism into which the egg develops. Or one factor may completely dominate the other, the organism bearing the impress of that factor alone, the other lying dormant. When, for example, in the egg of the rabbit, the factors for blackness and whiteness are brought together, the factor for blackness being dominant, the egg develops into a black rabbit. But now as the germ cells are formed which will give rise to the next generation, the factors are supposed to be sorted out among them in such wise that any one germ cell does not get both, but only one, of a pair of factors. Thus, in our example, eggs will be produced having the factor for blackness only, and others the factor for whiteness only. Similarly with the sperm cells, some will have the factor for blackness, some that for whiteness. No germ cell will have both factors. This separation of the factors with the result that the germ cells produced in an individual are unlike, is the most important feature of the Mendelian hypothesis. Working on this hypothesis, it can be calculated what will be the proportionate number of individuals embodying any particular combination of characters which, through experiment, have been found to behave in Mendelian fashion. The hypothesis has received wide and striking confirmation in that the

results of the actual breeding experiments agree closely with the calculated expectations.

Such extensive use of the unit-factor hypothesis has been made that in the graphic language of the day an organism is sometimes depicted as a bundle of separate qualities, of so-called unit-characters, each the outcome in mechanical fashion of a single discrete germinal cause, which does not vary and which is self propagative. Viewed in this artificial light, biology assumes a rigid appearance far from its real nature, its task appearing twofold, to discover through cross breeding the elementary or unit characters of organisms and the laws governing their combination.

It should be said that such a conclusion is implied rather than positively stated in the writings I have in mind, and is expressly condemned by some prominent students of Mendelian heredity (T. H. Morgan). The facts of paleontology, anatomy and development demonstrate how artificial it is, for they show that every part and process varies among the individuals of any one time, and the *mode* or typical condition changes from age to age. Moreover, the parts of the body are so interconnected materially and their activities or functions are so interassociated, that to speak of the body as a group of units is misleading. It is to misuse the license that is only allowed in allegory, or in science for the purpose of facilitating description. A tiled floor is composed of pieces which can be taken apart and recombined. But an organism, Olivia for instance, is not a mosaic, for the items in her inventory, as "two lips indifferent red, two grey eyes with lids to them" are not separate and independent components. The essential features of an organism appear to be as closely associated, fully as inseparable, as are the corners, cleavage, color and lustre of a crystal, of calcite, for example. For given the right conditions, the germ cell or other regenerative mass will always produce them.

I hasten to remind you that "unit-character" in technical studies on Mendelian heredity has a definite meaning, referring to the class of differential features, which mark off the individuals of a race, or of allied races, one from the other. Such would be the color of the eye perhaps, or the fulness and curve of the lip. It is, as already said, these contrasting features in respect to which the two parents differ, which behave independently of one another and which may therefore be recombined in various ways.

The question as to the permanency of such characters in hereditary lines is interesting to all of us. There is no doubt that they are remarkably constant and persistent, but experimental breeding amply demonstrates that they are subject to the sudden changes known as mutations. It has also been demonstrated that in the course of selective breeding they undergo change (W. E. Castle). They show then, as do the many series of intergrading organisms, that the rule of heredity over living things is not absolute. Living things, in fact,

continually escape from its tyranny through modification of their germ-cell substance, modification which is brought about through interaction with the environment and through interaction with other germ-cell substances, the latter action leading not only to new combinations of the old, as in ideally strict Mendelism, but to actual change in the specific protoplasm, with the result that what are virtually new qualities emerge.

Mendelism has enormously increased the general interest in heredity, than which no subject in the whole field of science is more discussed to-day. In the midst of the discussions and admirable investigations dealing directly with this matter, it is well not to forget what heredity is. As Haeckel pointed out long ago, heredity is not a special organic function, but is only a name for the fact that the specific substance of the germ cell exhibits a set of properties substantially like those of the parent germ cell. In other words, heredity means that an egg behaves very much as the parent egg did, because, having essentially the same organization, it reacts to stimuli in essentially the same fashion. A sound knowledge of heredity is therefore dependent on a knowledge of the ways in which the many kinds of protoplasm respond to stimuli; in other words it is dependent on the general level of biological science.

In conclusion, let me say that the several aspects of zoology at which we have glanced has each an interest in itself. Otherwise there would be no hope of advance. But they fade into one another. The data overlap and the problems merge. The geographical explorer, dealing with the distribution of animals; the classifier, discovering and arranging the diagnostic features of races and species; the descriptive anatomist skillfully tracing out details of structure in finished product and embryo; the comparative morphologist, outlining embryological sketches and life histories and applying his data to questions of evolution; the analytic embryologist, unraveling physiological factors, control of which enables him to bring into being the differences which he started out to explain; the student of hereditary transmission recording the way in which characters reappear, and his other half, the student of variation, who experimentally induces new differences—these and many others are all dealing with one and the same nature, the many-sided world of living and once living things of which we form a part. The various classes of phenomena exhibited by this world of organisms, as they are mapped out and in some degree analysed, enter into and constitute biology. They form a vast and heterogeneous array, of which it may be said that the vastness will remain, will indeed steadily increase, but the heterogeneity should become less evident. For as knowledge grows and hypothesis gives way to generalization, the various aspects of the living world will no doubt arrange themselves in a more and more coherent manner, that is, we shall be more and more able to assign them to empirically learned causes, to the fundamental powers of the group of protoplasms as shown in responses to stimuli.

THE OCEANS: OUR FUTURE PASTURES

By ZONIA BABER
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DURING a six months' trip last year to Australia and the South Sea Islands, seventy-nine days were spent upon the desolate Pacific Ocean. Beyond the bird zone that encircles the land the infinity of lonely waterscape was relieved by two whales, a few flying-fish and a small number of albatross. Days passed without a sign of life. Such an experience might well stimulate in any one an intense desire to reclaim this terrible desert, this lifeless expanse of moving monotony. Were the sea well stocked with whale, seal, dolphin and other oceanic mammals, the interest in sea travel would be tremendously enhanced. The pleasure and entertainment of the sailors and travelers would, however, be but a small part of this beneficent reclamation.

Humanity has always been in search of "pastures green"! As land increases in value, the grazing animals are driven farther away from the centers of population to the cheaper lands or regions that are untillable. It would be considered very poor economy to graze land that would produce one hundred bushels of corn per acre. The "moving on" of the "cowboy" is his dominant attribute. Even in Australia, the continent new to European endeavor, the same story is repeated. The land near the settlements that can be cultivated with profit must produce cereals and other vegetable foods; hence the cattle and sheep are driven away into the "back blocks." Just how long this trekking of the cowboy can continue can not be stated in years. Yet it does not require a very fertile imagination to see that the time is not indefinite. When the human race takes the next step in progress and changes its goal and ideals from *things* to *people*, from the making of numerous and wonderful things to the production of strong and wonderful people, wars will be found only in the records of the savage past. Then the normal increase of humanity will make it necessary for the earth to produce its maximum of vegetation for food and clothing and the cowboy must be pushed off the land.

In our first geography we learned that the surface of the earth is three fourths water and one fourth land. This fact alone tells us that multiplying humanity must secure a great part of its food from the sea. When we can no longer afford to graze our sheep and cattle on the land, whence can we secure our beef and mutton? A survey of the

future reveals this possible meat supply in the marine mammals. If we do not soon take heed, there will be no mammals in the sea to furnish meat. Man has been so criminally or stupidly wasteful of his earthly inheritance that he has bankrupted posterity in many things on both land and sea What a story of a warfare of passive resistance the marine mammals might tell! The history of the whale, manatee, dugong, sea-cow, seal and the walrus would bring the blush of shame to the cheek of the humane reader.

The whale, the largest of living creatures, believed to be the largest animal that has ever lived on this globe, no doubt attracted the attention of the earliest people. In ninth-century European history there is record of whaling. Yet it did not become a serious matter from the standpoint of the whale until the sixteenth century. Then the French and the Spanish greatly enhanced their riches through the products of the whale that frequented the western coast of Europe. Whaling became a great European business in the seventeenth century. After the right or baleen whale was found in such great numbers by Henry Hudson in 1607 during his first voyage to Greenland and uninhabited islands of Spitzbergen, the center of whale-fishing was transferred to that region. A thousand or more were slaughtered there yearly for many years. Writing of this period in 1820, William Scoresby said that the whale-fishing "proved the most lucrative and most important branch of natural commerce which had ever been offered to the industry of man." In 1814 a Scotch whaler is reported to have secured a catch valued at $102,840. Such rewards greatly stimulated the whaling industry. "Killing the bird that lays the golden egg" has never proved to be good business. The city of Smeerenburg in Spitzbergen, that grew to a population of 20,000 people in consequence of the whaling industry, was deserted when the whales were gone.

When the Pilgrim Fathers came to this country the whale was numerous along the coast of New England and became an important industry of some of the colonists. In 1846 the United States had a fleet of 680 whaling-vessels. More than $70,000,000 was then invested in this industry. Such slaughter naturally depleted the number of whales in the Atlantic Ocean. The whalers then found their way around the Horn to reap rich harvests in the Pacific. Scammon says in his "Marine Mammals" that in the early fifties of the nineteenth century from 30,000 to 40,000 California or gray whales passed along the coast of California annually. These graceful creatures, forty or more feet in length, passed along the coast within observational distance from the shore between November and May. Large numbers of females came into the lagoons to bring forth their young. There the whalers took advantage of the affection of the mothers for their young to lead

them to their death. To-day one may travel for thousands of miles in the Pacific without sighting a single whale.

The whale has been valued by commercial people for oil extracted from the insolating blubber that envelops the animal's body, and for the baleen, or whalebone, that hangs like a curtain supported from and extending around the upper jaw. The price of these commodities has greatly fluctuated. The price of whalebone has varied from 12 cents per pound in 1821 to $6.70 per pound in 1891. In many catches in past times the blubber only was saved, as the whalebone was not considered worth the trouble in taking, and the space occupied aboard. After the discovery of kerosene, oil became so cheap that only the whalebone was saved from many a catch.

One valuable product has for the most part been overlooked. At the whaling station at Green Bay, Spitzbergen, in the year 1910 they were saving the baleen and blubber, but throwing away the meat, which looked like good beef, to the apparent delight of thousands of seagulls. It was estimated that the meat of a whale about sixty feet long, that was being flensed, was equal to that of seventy head of cattle. Is it not criminal to waste this nutritious meat when there are thousands of hungry people? Japan, thrifty and adaptable, has used this valuable food for many years. A few years ago fresh whale meat sold in their market at 7 to 15 cents per pound, according to quality. All varieties are not equally prized for food. That which can not be sent to the city markets in good condition, owing to the weather or distance, is canned at the stations. It is reported that some whale meat if properly treated can not be distinguished from good beefsteak. A considerable amount of whale meat is utilized by butchers in Norway. Whale meat is also tinned in New Zealand and sold to the native South Sea Islanders.

In spite of the cheapness of oil and the use of steel and featherbone instead of whalebone, the slaughter of the whale continues. The whaling station on the Falkland Islands, alone, reported for 1910–1911 whale product worth $2,042,500.

Other marine mammals also share the fate of the whale. The manatee and the dugong live on vegetable food and must find their pastures of seaweed, algæ, and freshwater plants near the land. This brings them near to their arch-enemy, man, and has resulted in their life histories being almost completed. The dugong, ranging from eight to fifteen feet in length, was very numerous in the tropical seas of the eastern hemisphere. It has always been highly prized for food by the natives of the warm coasts of Asia, Australia and Africa. Although the female dugong produces but one young each year, the extermination of this harmless beast was not threatened till the European appeared, spreading his deadly plague of commercialism. A few manatee may

yet be found along the coast or near the mouth of some South American rivers.

The northern sea-cow, the rytina, found at one time in the shallow waters of the Behring Sea, was exterminated by the Russian hunters by 1768. The inactive habits of this sea creature, the palatableness of its flesh, its size—from twenty to twenty-five feet in length, its fearlessness of man, and its affectionate disposition toward its kind, led to its extermination.

The walrus, another huge sea mammal, is unfortunate, from the point of view of his continuing to be an earthly inhabitant, in possessing tusks of which man can make use. It is stated in *The National Geographic Magazine,* March, 1911, that "fifteen years ago walrus tusks from Alaska sold in San Francisco amounted to 10,000. Now the sale is less than 100 per year."

The seal has always been an important, if not the most important, article of diet for all Arctic peoples who have not possessed reindeer; and it must be with a feeling of shame that we read that the Alaskan fur seal, estimated to be 4,000,000 in 1867, was reduced to 150,000 in 1911. We find comfort in the results of the deliberation of the International Fur Seal Conference in 1911 by Great Britain, Russia, Japan, and the United States. These four great powers agreed at that time to give the fur seal a form of protection in the North Pacific Ocean for fifteen years. It is hoped that the knowledge gained by these four seal-killing nations during the two months' deliberation of the Fur Seal Conference will result in the preservation of the seal for all time.

Mankind would be endowed with an abundant food pension if an international closed season could be declared for all marine mammals except the killer whale—the only one that destroys warm-blooded animals—until these valuable sea creatures could multiply in sufficient numbers to replace in part the position in the food supply now occupied by sheep and cattle. This suggestion may meet with strong opposition at first. We are always suspicious of the *new*. *Newness* explains the attitude of repulsion for any novel food.

Our attitude toward food is almost wholly on the emotional plane. Few people "eat to live"—"we live to eat." The query of the average person in regard to any unaccustomed food is: "Is it good?" meaning, "Does it please the taste?" He does not ask: "Is it nutritious?" "Will it feed the body?" We forget that we have learned to like all food. Some children must be taught to take milk. Persons very sensitive to taste may be slow in learning to like a new and disagreeable taste. But any one who tries can learn to like any food that is not poisonous to him.

The individual who is suspicious or afraid of new ideas, unknown people, strange animals, unusual landscapes, is called provincial. The

same term may be applied to the person who can not eat this or that wholesome article of diet. The cosmopolitan has been obliged to eat strange foods when traveling in foreign lands. By so doing he learns to like foods which he thought unpalatable when first introduced.

Hunger of sufficient intensity gives relish to any wholesome food, however strange. Explorers in the Polar regions often have been obliged to eat the flesh of the seal, walrus and whale to save their lives. We have been told that the flesh of the Australian dugong tastes like beef and is easily digested; that when salted it has the flavor of excellent bacon.

Why trouble about these strange sea monsters now? We still have plenty of grazing land! If one may generalize from past records, the sea mammals will be extinct when the grazing lands of the earth are all under cultivation. It is reported that in 1690 an inhabitant of the island of Nantucket, which has very poor soil, looking at the whales playing in the ocean said: "There is a green pasture where our children's grandchildren will go for bread." He considered the ocean from a commercial point of view. We now observe as we look at the waterscape of the world: "There is a green pasture where our children's grandchildren, far removed, will go for meat."

To the credit of humanity it can now be stated that the thinking, ethical nations are setting aside sanctuaries and preserves for birds, other animals, and plants that are liable to become extinct. One nation alone, however far-seeing and altruistic, can not conserve the marine mammals. This is an international concern and it might well be brought before the next international conference at The Hague.

WHAT'S IN A JOB?

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MEN and women should rejoice in their work. Not simply because, as Solomon intimated, that is their *portion;* but because that is their *life.* The world's work occupies more than half of the waking time of the world's workers. A business man or a professional man often takes the problems of his occupation with him into the hours of "leisure," and even to his bed. But even the irresponsible workers who do not have to worry—about the work—after the whistle blows spend most of their waking hours with the job. In other words, the largest part of the life that counts, the life of which we are aware, is put in at the process by which men and women obtain the means of livelihood.

In the various demands that have been made from time to time for greater fulness of life, for life more abundant, people have asked for "shorter hours"—for more leisure—generally. Too few have directed attention to the possibilities of life within the hours of work. The artists have been looked upon as people who got their fun out of life by working all day at the sort of thing they like to do. The boy envies the professional baseball player, because the latter *plays* and gets paid for it besides! Indeed, the other fellow's job is often apt to look like play to us; but our own job, our own way of living and of making a living—that is hard work, and no fun.

The many social and civic surveys, the investigations into the industries, the "vocational" propaganda and the preachments of various schools of reformers have all helped to direct attention to the question of the individual's job. And we learn with a variety of emotions that in all except the strictly agricultural and the strictly mining communities the occupations of over ninety per cent. of the people are determined by the "finding of jobs" by boys and girls who are "willing to do anything." That is to say, more than ninety people in a hundred have no positive voice in deciding upon their "life work."

This idea, "life work," is indeed foreign to the mass of workers, though most of them are doomed to hard work for life. The expression suggests something in the nature of a *calling,* in the literal sense of that word, and it intimates some connection between the purpose of life as a whole and the character of the work. The missionary feels a calling, and he devotes himself to converting savages or saving

sinners, prepared to make every sacrifice that the service may demand. We know of physicians or nurses who look upon their work as a calling; we can even imagine a grocer who looks upon his task as in the nature of a mission—he may feel that he is sent to distribute to the multitudes their daily bread, in various kinds of cans and bags and bottles and packages, gathered by him for this purpose from the four quarters of the globe, through the intermediation of the wholesalers and jobbers. But it seems almost ridiculous to speak of the calling to paste labels on bottles of fraudulent imitations of fruit syrups, or to address envelopes for an advertising concern.

The fact is that most workers have no calling or vocation whatever, that most of them have not even any pride in their work, certainly no moral enthusiasm in connection with it. Moreover, most workers change their occupations so many times that any possible spiritual connection between the work and the wholeness of life is rudely broken. Nor do these changes correspond, in general, with stages in mental or moral development, or with stages of technical proficiency. They correspond for the most part with such stupid and irrelevant facts as these:

Boss went out of business.
We moved across the river.
The new foreman cut down the force.
Laid off—slack. Got job in biscuit factory.
They changed to piece work.
New director put in his nephew.

Well, we know what these things mean.

But now that attention has been directed to the need for a deliberate choice of a "vocation" as well as for a systematic preparation for it, the question of what kinds of jobs there are, the question of what the jobs demand and of what the jobs offer must come rapidly to the front. A given employment may be entirely satisfactory to one type of person, and a living hell to another. But, in addition to that, there are some people who are practically worthless for any job; while there are many jobs that are not worthy of any human being.

The United States Census enumerators have been sorting all of us according to a list of 9,326 "gainful occupations"—including yours and mine as gainful, although we may have different opinions on that point. Many of these occupations represent merely minute subdivisions of work in special industries, like the "collator" in a bindery, or the "puller" of basting threads. No one person, not even a reasonably small group of persons, knows all the important facts about all these occupations, except perhaps in the case of the so-called professions. But the occupations are grouped about large industrial processes, so that many of the important facts are true for whole families of occupations.

Every year thousands upon thousands of girls and boys leave school and begin to "look for work." In contemplating a proposed job, or occupation, or industry, every young person, as well as his or her parents or sponsor, should be able to consider carefully the conditions and the possibilities of the work.

First of all, it would be obviously foolish to prepare for a job that may be obsolete by the time the worker has achieved a fair degree of skill at the work. Since the introduction of power machinery into practically all industries, rapid changes in the character of the work required of the individual have been going on. An unimaginative boy who decides that he will do the same work as his father is now doing is likely to find when he gets to the working age that the job isn't there any more, or that it has become an entirely different thing from what it was in his father's time. There is no use in training children to become candle-dippers or flint-chippers, for example. Candles are used comparatively little now-a-days, and are likely to be used still less in the future; and, besides, they are practically all made by machinery. Flintlocks are used only on the stage, and there they can be just as effective without the flints; besides, not enough would be used to keep a full-sized person busy for a life time. The first question about an industry or an occupation is therefore a statistical one: is it a growing or a declining industry? Then, how many people does it employ, what are the chances of getting a start in it? And what does it mean, quantitatively, for a given locality? In parts of Russia, platinum mining offers openings for young men; but what we want to know is, what are the prospective openings for our sons and daughters near home?

However, one can change his locality, so that it might be reasonable, under certain circumstances, for a city girl to prepare herself for the business of scientific chicken expert, or for a farm lad to become a wireless operator. But we can not very well live at a time very different from that in which we happen to live. Without regard to locality, then, government statistics are to be consulted first of all. From these we can find that the business of the carriage builder is going down (and every schoolboy knows the reason why), whereas the chemical manufacture is going up; private practise of medicine is going down, whereas the number of health officers and medical inspectors and hospital surgeons and nurses is going up. We have too many lawyers, but we have not enough scientifically trained specialists on corn or cabbage or cotton or insects or bacteria.

A second important question to consider is that of possible restrictions as to race or color, for example. In the city of New York one of the public schools is in charge of a negro principal, who has under him a number of white teachers, and white as well as colored pupils. This may be interpreted to mean that there is here in the teaching business

no restriction as to color. Nevertheless, this condition is not true of the teaching business for the country as a whole, and the situation is exceptional even for the northern states.

The whole race question is closely tied up with the economic one, and there is a tendency, in mixed communities, for the races to become segregated into restricted occupations. In the cities there is practically no opportunity for a negro girl as a stenographer; on the other hand, a white man can not become a porter on a Pullman car. If a man prefers a Japanese butler and will not consider the application of an Englishman, there is the same kind of discrimination. Indeed, the discriminations shown in the economic field are not so much influenced by race prejudice as might be supposed, although this insidious type of narrow-mindedness does enter, of course. An illustration in point is the fact that the employment agents of a number of large high schools for boys reported great difficulty in placing Italian, Hebrew and negro boys with business houses. One of these agents explained the situation as follows:

"They don't want negro boys because they do not expect any to have the ability to become responsible officers in the business. They object to Italian boys on account of the outlandish names. They object to Hebrew boys because these are too ambitious."

"They" meant business men of all kinds—*including Jewish business men!* "Too ambitious" turned out, on enquiry, to mean that many of these boys are not content to remain at a routine task for a long time; that they will even leave one employer to go to another in order to learn a new line of work; that they are too impatient for promotion.

The most varied group of considerations is found in connection with the physical conditions of an occupation. The conditions of work in the packing industry were so vividly described by Upton Sinclair in "The Jungle," that many people upon reading the book resolved to become vegetarians. As the author says, he tried to reach the heart of the American people, but got no farther than the stomach. We still refuse to consider how the workers work and live.

The question of sanitary surroundings is in itself a complex one. We have all been impressed with the importance of suitable ventilation; we have not all yet learned to insist upon it. Then there is the question of temperature. One may work in a refrigerating room of a packing house and have constantly cold feet and blue fingers; or one may work before the open furnace of a steamship, or the oven of a bakery. The "top-filler" of a blast furnace used formerly to be exposed to almost unbearable heat, but in the modern plants much of his work is done by mechanical devices. Yet there is great variation in the conditions under which he now works. In some plants the top of the furnace is exposed to the wind, and a hose furnishes water for cooling off

the plates on which the men stand, so that the temperature need not be higher than that of a warm summer day; in other plants the top is enclosed so that the men are compelled to run away from the furnace at frequent intervals, to avoid complete collapse, the temperature often running up as high as 120° to 125° Fahrenheit.

Changes of temperature are also important. The glass-blower's helpers were required to run from in front of the furnace to the cold outside air, back and forth many times a day or night. Mechanical devices are gradually making this kind of exposure unnecessary, because uneconomical, to the employer. The humidity or the dryness of the air should be considered. The laundry worker exposed to a supersaturated atmosphere stands at one extreme; at the other is the worker in a flour or textile mill. And there may be much in the air besides moisture.

The dusty trades have often been described as prolific sources of a large part of our tuberculosis. There is not much choice between the dust of a cotton mill or of a grinding shop, and the dust inhaled by the breaker-boy at the coal mine—which fills the lungs so thoroughly in a few weeks that years in a clean life away from the mines can not remove it all. The employer can eliminate this dust in all industries practically, as soon as it is worth while—in a money sense. If the workers, for example, were in a position to insist upon dust-free work rooms, or if they exacted a large bonus for every cubic foot of dust that they swallowed or inhaled, it would soon be found practicable to install dust-preventing or dust-removing devices, as has already been done in many establishments. It is likely, too, that much of the dust thus saved could be converted into useful and usable commodities.

Gases and fumes are a source of annoyance, and even of injury, in many industries. In gas factories it is now economical to save all the ammonia and the other "waste" products of the coal distillation, because they have a definite commercial value. But in many clothing factories enough illuminating gas escapes from the neglected pipes and joints to be positively injurious to the workers. On the other hand, the atmosphere in a malting house or in a brewery often contains large amounts of carbon dioxide, but this is really quite harmless. The fumes from special solvents used in many paint shops and picture-frame factories are very injurious, especially to those who have not perfectly sound hearts.

The matter of light and sound deserves attention. There is as great danger from too much light and glare as there is from insufficient light and consequent eye-strain. Manufacturers have found it to their interest to standardize lighting conditions, because the output per worker has been appreciably increased as a result of such standardization. There are still, however, many workers who are exposed to a

constant flicker, or to a rapid alternation of light and dark. In some of the needle trades the needles in the machines move so rapidly that it is impossible for the operator to watch them directly for the purpose of controlling the machine; there is therefore suspended above the machine a strong electric light which shines into the eye of the worker as well as upon the needles; and she must watch the flickering reflection constantly.

The fact that most factories are noisy places is a serious one for the worker. It has been found by experiment that the constant noise produces an undesirable effect upon the nervous system of the worker, as well as upon his physical efficiency. In the presence of the noise the body tires more easily, and the monotony and rhythm of the noise have a tendency to dull the mind—very much like mother's lullaby. However, some of us are much more sensitive to these effects than others, and if you advertise for boiler-makers you will no doubt receive a number of applicants.

The posture in which the work is carried on is important. In many trades it is practically impossible to produce maximum results except in a standing position; and when you are paid by the piece, that is to be considered. In other trades various kinds of stooping and bending are required, although the scientific manager is gradually changing machinery and processes to avoid such awkward situations—it has been found more productive to avoid stooping. The modern builder does not allow his bricklayers to bend over for the brick and mortar; since Gilbreth showed that the output of the worker could be doubled by means of his special platforms and motion system, the bricklayer may hold his body erect all day long. While walking is considered to be "good exercise," there are some people who should not become letter-carriers; while sitting is often "very restful," there are many men and women who are not constitutionally able to thrive in a sedentary occupation.

People inclined to rheumatism should avoid occupations in which one must be much on a wet floor, as in certain chemical shops, or in slaughter houses. In some processes the worker must expose the skin to the action of various chemicals that are more or less injurious. Some skins are so sensitive that they find the relatively mild chemicals used in photography exceedingly irritating.

The question of accidents should not be overlooked. In some occupations daily accidents are accepted as a matter of course; in others they are exceedingly rare. In the steel industry alone there is considerable variation. If we take all the workers in that industry for whom records were available in 1910, we find that the accident rate was 245.2 per thousand workers (allowing 300 days of work to the year). Of these 2.72 per thousand resulted in permanent injuries, while 1.86 accidents were fatal. Now in the puddling process the rate for the same

year was only fifty accidents per thousand workers, and none of the accidents resulted in permanent injury or death. On the other hand, in the Bessemer steel works the accident rate was more than eight times as high—423 per thousand; and of these three resulted in permanent injury to the victims and 4.36 were fatal.

In addition to the frequency of accidents, one should consider whether the accidents result from the nature of the processes or machinery, from the worker's own carelessness, or from the carelessness of fellow workers. Many industrial accidents and diseases are avoidable through ordinary care on the part of the worker; in other industry special safety devices are available—although not always used.

The fire danger differs greatly with different occupations, as does the danger from explosions, special diseases, etc. A great deal of study has been given to this subject, especially in Germany and England; but the results of our own studies in this country are not yet available to the people most concerned, namely, those who through ignorance of the dangers annually enter upon these occupations in large numbers for no other reason than because jobs happened to be open just at the time when they happened to need jobs.

Even more important problems, but some that have received but very little consideration, are those that bear on the moral conditions of work. Take a dozen occupations with which you are acquainted, and answer for each of them this question: "Is the work justified morally, or does it rest upon the exploitation of vanity, or stupidity or ignorance or helplessness?"

In the middle ages, when the ideals of craftsmanship reached the climax of their development, men put religious zeal into the hammer blows that went into the building of a cathedral; and women worked with fervor upon the tapestries for a shrine. Such work was done for the glory of God; other work was done for the service of man. And even where it was not voluntary or enthusiastic work, the end of it was fairly clear. But to-day most industrial and commercial workers have lost the connection between the particular processes in which they are engaged and the service or glory that are to come from the work. As a result of the many fine subdivisions in the world's work, the carpenter may one day be placing wainscotting in a church, and the next day finish up the card room of a gambling club. He can not ask any questions either as to the denomination of the ultimate worshippers, or as to the legitimacy of the card games. Neither may the printer in the card factory ask whether the cards he makes are to be used for domestic euchres or for three-card monte.

Yet there are other occupations whose results contribute more directly to morally unacceptable ends. There is the making of all sorts of imitations of use and beauty: from gold bricks and counterfeit coin

to brass "jewelry" with glass gems; from fall-apart furniture to tinder-box tenements; from faked foods to murderous cure-alls; from paper shoes to shoddy. Can any person continue to manufacture and sell nostrums that are worthless—or worse—with a "ready-relief" label, and still maintain his self-respect? Can a girl design labels and wrappers and display-advertisements for this nostrum, and still maintain her self-respect? Can a chemist advise how fraud may be concealed, can a lawyer advise how the law may be evaded—and still maintain his self-respect?

Yes, yes: people want jewelry, and since they can not afford fine goods, we please them by making for them the nicest that can be had for the money that they *can* afford to spend. People want to have as handsome furniture as any they see in the stores; we give them some that *looks* just as nice as the finest—for a while. People want to be as well dressed as their employers, so we give them near-wool in stylish patterns. And all the time we shriek out loud—as loud as we can afford to—through the advertising pages and posters and sky-illuminators, urging the people to buy, buy, buy!

Very probably, people are not coerced into buying. And there seems to be *some* logic in the common attitude "They are going to spend their money anyhow, so we may as well take it." But the logic is that of the highwayman, the logic of the exploiter. There is *some* truth in the manufacturer's or the dealer's shrug which says, "It is our business to supply the demand." But the other side of the truth is that half of your efforts are devoted to creating the very demand in question. At any rate, while men will persist in getting drunk, I don't want my son to supply them the whiskey. While some men persist in losing all their savings in an attempt to get something for nothing, through a sure tip on the races, or on the stock market, or on some hopeful fool's gold-mine—I do not feel that I have a right to take their money, even though I do need it in my own business.

But most young men and women who are set at work can not find the connection between the special tasks they are performing and the ultimate service or fraud to which they contribute. There is, however, a side of the occupation that ought to be more clear. For example, is a girl asked to serve all day—at a "living" wage—surrounded by women fixed up in all the frills and fineries that the fashions permit? Or does a young chap have to carry messages that reek with foulness and corruption? In New York a state law prohibits the employment of minors as messengers during night hours; but girls may still be placed in all kinds of department stores. And in some of these stores, if a girl complains to the superintendent that the elevator man or one of the "higher" male employes has insulted her, she is disciplined by being discharged, while the gentleman in question is cautioned to be

more careful next time. Girls may still hear all sorts of things over the telephone wires.

Again, what are the temptations peculiar to the conditions of a given occupation? What are the temptations of a young musician who can find steady employment chiefly in a "music hall" or in some all-night eating place? What are the temptations of a person who is exposed to the receiving of tips? What are the temptations of an occupation that takes one away from home for long intervals, or at frequent intervals?

Yet we must guard against wholesale condemnations. There are some occupations that are absolutely impossible. But in many occupations the moral difficulties are relative: that is, one type of person can overcome temptations that another should not be exposed to at all. In the same orchestra, one musician will climb to the top in the same time that another goes to the dogs. One man may become a pawnbroker because he sees in that calling an opportunity for greater service to his poor neighbors; another sees in it not only the main chance, but he sees that as a shark does.

The complaint is now continuous that our schools fail to do what the little red school house did; that girls and boys leave school and in a few years lose all their intellectual interests. The facts can not be denied. The important question is to locate the determining factors in the situation. Again and again have investigators found that the monotonous, mechanical jobs have not only destroyed all intellectual interests, but have actually driven the ability to read from the minds of the young workers. These acquired arts of reading and writing are but superficial additions to the mental life, and can hold their place only through constant practise. Even more true is this of the habit of thinking. The nature of the work that the girls and boys are called upon to do plays a significant rôle in the mental development. Some kinds of routine work, while they do not call for mental exertion, at least permit quiet thought. Cobblers and tailors were formerly notorious as metaphysicians. But where you have to watch a machine constantly, to avoid damage to yourself or to the material, the attention is held while the operation does not add to the content of the mind. The tendency to standardize operations constantly reduces the opportunities for initiative and thought.

In other kinds of work there are many *outside* opportunities for mental enlargement. The salesman is obliged to meet human beings and to adjust himself to them at a thousand points, although what he can learn from his "line" may be very narrowly limited. In a factory for making electrical equipment or chemical products, an alert person will find suggestions for outside study, although he may be tied to a narrow round of operations within the day's work. While a cook

performs a limited number of operations in her work, there is constant opportunity for devising new combinations without limit, although hers is not usually considered a particularly intellectual occupation. Some girl who likes cooking may find in this work boundless opportunities for intellectual growth, while a hundred boys and girls become merely cooking machines.

It is a characteristic of so-called professional work that it demands constant growth. This does not mean that every lawyer or minister or teacher is constantly growing. Unfortunately it is possible for a physician to keep himself going a number of years on a few cheerful phrases and an assortment of pill-bottles; it is possible for an architect to make some sort of a living with a limited repertory of plans. But professional work is nevertheless of a kind that gives endless opportunities for thinking and learning and experimenting—in short, for growing. The same is true of many occupations that are not considered professional; that is, they may become mechanical routine, or they may be used as instruments for personal enlargement. Library work is a good example; stenography is another. In a particular library or in a particular office, the worker may be confined to routine operations indefinitely. Here we must distinguish between the vocation and the particular job. Indeed, this distinction is important in every department of economic life. For a person who has learned a special trade, one shop offers great opportunities, while another shop is a trap without an outlet.

In every occupation there must come times of great exertion that may leave one exhausted. But in some occupations the work is always pitched to the limit of endurance. In every occupation there come moments of suggestion or inspiration; but in some occupations there is stimulation every day. In some occupations the worker may set his own pace and produce—and earn—in accordance with the mood, or his energy, or his health; in others the pace is set by the machinery or by the speed of the fellow-workers, or by the character of the process, and the worker is under tension all the time.

The significance of these facts can be seen in their relation to the leisure life of the worker. One who finds his work stimulating is capable of enjoying life vigorously after working hours; one whose work is enervating becomes sodden, or seeks artificial stimulation in liquor or in dissipation. At best, the exhausted worker goes home to sleep until the next day; at worst, the drunken worker sobers up for another day's grind.

The hours of work determine the amount of leisure as well as the energy available for that leisure. But some men get more out of life with ten hours a day at their tasks than others get with only eight or six hours. The physician occasionally works twenty-four hours at

a stretch; he must frequently interrupt his sleep to attend a suffering victim of disease or accident. But he does not count his hours. A bookbinder must sometimes work twelve or fifteen hours at a stretch, or even more, two or three days a week, only to be laid off or given part time for the rest of the week; and that is a serious hardship. In many processes in the steel industry the twelve-hour day, seven days a week, was for long the accepted condition. Only within two or three years has any considerable effort been made to change the system to eight-hour shifts, seven days a week. Many occupations are seasonal, allowing many free hours during the year, but these are seldom so organized as to be of value to the workers in any sense. In the telephone service the operators in the best centrals work only six or seven hours a day, and have several interruptions for rest and relaxation; but fainting is a normal episode in the day's work.

The question of hours is closely connected with that of pay. It is possible to make a fine statistical showing of a high rate of pay per hour, where the worker makes a bare living and takes nearly all of his waking time to do it. For example, in a number of city railway systems it takes a conductor or motorman fourteen or more hours to put in ten hours of work. They get paid for the time of the actual "run" but have to wait at the barns several hours a day, to be on hand when wanted; this with systems of shifting reduce the weekly earnings to very moderate figures indeed. A tailor who works only thirty-five or forty weeks a year should receive his whole year's income during the working weeks. What sometimes looks like a high weekly wage in certain industries is subject to just this kind of reduction. Comparisons are sometimes made between weekly or hourly wages of different classes of workers without taking these facts into consideration, and the conclusions are accordingly misleading.

Another problem connected with the wage is that of mode of determining pay. In the first place, is pay made by time, or by piece, or by week, or by the year? There are many elements that enter into the determination of a system of payment, and it would not be fair to say that any one system is the best. But the system has undoubtedly a profound influence upon the attitude of the worker toward his work. The "ambulance-chasing attorney" is obviously influenced by the fact that he is a "piece worker." On the other hand, most *soldiering* is done by men who are paid by the hour or the day. An ideal system of payment has not yet been worked out, although many improvements have been suggested upon prevailing systems. Still, some plans are more advantageous for some people than others, and one should certainly think of this in considering a vocation.

There is another side to the wages question. Does the wage grow rapidly, or slowly, or not at all? In some manufacturing processes

a girl may attain the maximum wage in two months; but under such circumstances the maximum is always low. The thousands of boys and girls who leave school to go to work every year receive an initial wage averaging about $2.50.[1] The majority of those who receive considerably more than this enter occupations in which there is absolutely no training for higher efficiency and for higher income. In other words, a high initial wage means, in general, a low ultimate wage; for what is a high wage for a boy or a girl is a low wage for a man or woman, and in many industries a few years of work render the worker incapable of acquiring higher earning power.

Finally, how are the wages regulated? Does each worker come in and bargain for the best terms he can get, or are there standard schedules of pay, such as sliding scales or the like? Or is there a system of collective bargaining, such as has been recently adopted in a number of the clothing trades, and in part of the book-binding trade? What are the personal relations between the workers and the management, or employers? Can one maintain his self-respect, or must one sacrifice it in one of a hundred ways to hold his job? For example, does one have to "jolly the boss," or contribute for a present to the superintendent on special occasions? Or is there favoritism in giving out the "fat" tasks; or is there nepotism in promotions? Or would you have to suspect that each of the workers near you might be a spy?

There are many other questions that one might ask about each occupation in turn; and very few indeed of the occupations that have been studied can give a frank and satisfactory answer to each question.

Every normal girl and boy is entitled to an opportunity to acquire a vocational training that will assure a competence under decent conditions later in life—to all who are willing to work. The basis for this claim is an economic one, as well as a moral or humanitarian one. Indeed, it is a morally just claim because it is economically sound.

Nearly four fifths of the girls and boys leave school between the ages of fourteen and sixteen years, quite unprepared to do work of a kind that will support them. The only kind of work that they can find to do is the kind that is "easy to learn" but, oh, so hard to do, day after day, and year after year. For the employer has neither the facilities nor the interest to train them. In a survey made in New York City of the jobs taken by children on leaving school, it was found that in over 77 per cent. there was no training whatever; in ten per cent. there was a "chance to pick up"; in 7.5 per cent. they were put at learning one process; and in five per cent. there was "some supervision." Similar results were obtained by investigators in other cities. Children in these jobs become in a very few years fixed in their habits of work, in their

[1] Within two years, that is, since the beginning of the European War, this figure probably represents the minimum rather than the average.

habits of thought and in their outlook upon life. They have in the meanwhile become young men and women, but have not increased their earning power: the result is that we have millions of men and women incapable of earning more than children's pay.

That this situation is wicked morally, hardly any one will probably deny. That it is necessary economically, hardly any one will claim. In the first place the marvellous increase in productivity during the the past fifty years would in itself be sufficient to justify the claim for decent living conditions for all workers. But the process of improvement is continuous, and has recently received added acceleration in the development of "scientific management." In the second place, every time that outside pressure or humanitarian sentiment has wrested from employers another slice of "welfare work," the reaction showed itself in the form of increased dividends. In other words, the humane organization of an industrial or commercial enterprise *pays*. In the third place, the employers are constantly complaining that we have not enough trained workers to maintain an effective competition with foreign manufacturers; that an increased skill on the part of the workers would mean relatively larger productivity. Presumably they intend that some of the gain shall go to the workers. At any rate, the implication of the claims of these experts is that high-grade labor is more profitable than low-grade labor, even under modern capitalistic conditions which have made so much of low-grade labor attached to machines. Finally, the admission of untrained children to business and industry brings about a pernicious circle from which there is no apparent escape. It results in raising up a population of men and women incapable of earning a living wage, and doomed, in consequence, to a parasitic life on a very low plane; and this makes impossible the escape of the succeeding generations from the bondage of low standards of living.

The question then is not, "Can we afford to train children for high-grade, efficient and happy lives?"—but, "Can we afford to leave out such training?"

In looking about for means of improving the situation, we may expect much from legislation. The agitation of the labor unions, of the consumers' leagues, of the welfare workers and reformers, must bring before us the need for remedial legislation, largely in the nature of restrictions upon exploitation and the protection of the public health. Legislation of this kind should be supported at every opportunity.

But more far-reaching than legislation is an attack upon the children. They must be taught what they have a right to demand, they must be inspired to insist upon their rights.

Is it too much to ask that the jobs we are offered shall represent useful, meaningful work—that they shall help to clothe or to feed or

entertain or enlighten our fellow beings? Is it too much to ask that the work which is offered us be placed in wholesome surroundings, free from corruption of the spirit as well as of the body? Is it too much to ask that our jobs shall permit us to grow while we work, and leave us a balance of energy to play withal? Is it too much to ask that human devotion to work shall be rewarded with life as well as with the means of life?

We must demand an *organization* of work and a *distribution* of workers that will yield a maximum of satisfaction and pleasure to the workers *while at work*. We must demand that in the planning of shops and factories, in the offering of jobs and in the selection of jobs, the first consideration shall be that these things are for the men and women who are to do the work, no less than for the human beings who are to direct the work, or who are to cut the coupons.

Men and women should rejoice in their work, for that is the most of their life.

SCIENCE AND FEMINISM

By ROBERT H. LOWIE, Ph.D., and LETA STETTER HOLLINGWORTH, Ph.D.

FEMINISM demands the removal of restrictions imposed on woman's activity. Opponents of feminism seek to justify these restrictions on two grounds: (1) because of undesirable social and ethical consequences that are believed to be the necessary outcome of their removal; (2) because of the alleged unfitness of women to undertake certain forms of activity. The considerations that come under the first head lie wholly outside the field of science; for what is socially or ethically desirable depends on the individual point of view assumed, and has nothing to do with the objective determination of fact that constitutes scientific judgment. At best social science might establish what consequences would actually flow from a removal of restrictions; but social science is at present far from being able to predict future events within its domain. Science, then, can deal only with the arguments of the second order, the question whether woman is by nature debarred from successfully following pursuits open to man, and the present paper is confined exclusively to this problem. It is true that some scientists have categorically affirmed woman's inferior equipment, notably Professor Sedgwick in a much-advertised statement in the *New York Times*. In so doing they have voiced folk-lore and folk-ethics rather than science. On the other hand, avowedly feminist literature has not been free from misrepresentation of the facts. The following pages are designed to fill the long-felt want of a concise popular summary of the present state of knowledge in regard to the question of woman's supposedly natural disabilities.

The widespread conviction of woman's inability in certain directions is in large measure due to the fact that, to the knowledge of those disqualifying her, she never works and never has worked in these directions; hence the desire on her part to perform such work appears "unnatural." This point of view is, of course, not a strictly logical one; for even if woman had been uniformly debarred from work along certain lines, this might have been due to special historical causes and not at all to her native endowment. The occupation of typist-stenographer is at present practically monopolized by women, while a few decades ago the corresponding secretarial positions were uniformly filled by men. Yet we do not attribute this fact to a change in the natural fitness of the sexes to perform the required work. Nevertheless, while the argument from universal exclusion would not be rigorously demonstrative, it must be

admitted that if women were *everywhere* shut out from a number of occupations open to men, regardless of racial and social differences, this would be fair *presumptive* evidence that woman is naturally less fit to undertake the tasks in question. Before making a direct comparison of the biological and psychological status of the sexes, we will therefore try to determine woman's sphere in different forms of society.

Woman's Sphere in Different Cultures.—Unfortunately this particular problem has been obscured by feminists as much as by any of their opponents. Among many adherents of woman's cause, there is a firm belief that all mankind at one time passed through a stage of society called "the matriarchate," in which women ruled supreme and men played the second fiddle. Only at a later period men are supposed to have risen to the ascendancy, hence, it is argued, the inferior position of woman in modern times is not rooted in sexual differences, but results from man's social position of vantage.

A correct conclusion should never be bolstered up by erroneous reasoning; and in the present instance the argument is scientifically worthless, because no satisfactory evidence of a general matriarchate condition has ever been advanced. The following are the facts: A great many primitive peoples of the world reckon kinship either exclusively through the mother or exclusively through the father; the matrilineal kin group being commonly called (by American ethnologists) a "clan," the patrilineal kin group a "gens." However, there are also not a few tribes without either clans or gentes; and in many cases there is not a shred of evidence for the view that the gentes were ever preceded by a clan system. Thus, it can not be regarded as a fact that the matrilineal clan represents a once universal stage of social development. But, even if it did, this would be very different from asserting a matriarchal stage. To trace descent through the mother is one thing; to yield social prerogatives to woman is a very different thing. Thus, we find a well-developed system of maternal descent among the coastal tribes of British Columbia, but though a man inherits his mother's clan name and his maternal uncle's property, women play an altogether subordinate part in the tribal life. It is true that instances may be cited on the other side: among the Iroquois, in particular, there is not only descent through the mother, but something approaching a matriarchate, *i. e.*, a far-reaching influence of women on the conduct of social and political affairs. Such examples, however, are decidedly rare; as a rule, whether in North America, Australia or other areas, the matrilineal system is *not* coupled with matriarchal privileges.

The really important question is, what has been the field of woman's activity in different times and regions? The care of the children devolves on her from biological necessity. This task and her inferior muscular powers would keep her from war and the chase. Are there any further restrictions which the consensus of human societies has de-

clared as inherent in sex? The answer of ethnology seems to be a clearly negative one. In every tribe there is indeed a division of labor between the sexes over and above what seems determined by the demands of infants and the differences in physical strength. But the types of activity associated with woman and man differ from tribe to tribe. Among the Hopi all the weaving was done by men, while among the Navajo, who are supposed to have learned the art from the Hopi, its practise fell to the woman's share. In North America the shaping of earthenware vessels seems to be a feminine pursuit; but in some sections of Africa men function as potters. It is not *a priori* obvious why the tanning of skins should be executed by women among the Redskins; why agriculture is the work of men among the Pueblo and of women among the Iroquois Indians; why the realistic painting of Plains Indian robes should be done by men; while the geometrical painting of rawhide bags is a prerogative of woman.

Without going into further detail, we may safely state that almost everywhere woman's contribution to culture is an important one. So far from being confined to the activities currently associated with the household, she often plays a most important part in the economic life, and practises indispensable tribal arts and industries. It is indeed true that these activities do not involve so sharp a separation from the household work as would result in modern conditions. An African agriculturist can ply her hoe with a child on her back; an Indian tanner may scrape and smoke hides, plait baskets and embroider quillwork in the intervals of domestic duties. But for our present purpose this fact is irrelevant. We are concerned with determining whether there are fields of work that woman should be debarred from for reasons of natural unfitness. What we actually find is that the work assigned to woman (beyond the obvious biological duties) is a matter of social custom, due doubtless in each particular case to specific historical causes. Ethnological evidence does not permit us to say that it is natural for women to exercise political functions as among the Iroquois, or to be rigidly excluded from tribal activity as in Melanesia and Australia; it does not prove that women are naturally more or less fit to be potters, weavers, tanners, gardeners, artists, poets or what not. It merely indicates in different communities considerable differences in the apportionment of modes of employment between the sexes. It does not justify the theory that the apportionment that had developed in our own civilization until the most recent times represents the one natural division of labor. If that conventional restriction of feminine activity is a natural one, proof must be given on other than ethnological grounds.

Biological Status.—Let us then turn to a direct comparison of woman's and man's biological and psychological status. Is woman by virtue of her organization anatomically and mentally in any way an inferior being?

As late as 1884, Paul Albrechts attempted to establish the "greater bestiality of woman from an anatomical point of view" by showing that in no less than nine points she approached more nearly to "our wild ancestors." In the tenth edition of Ploss and Bartels' "Das Weib"[1] Professor Paul Bartels exposes the absurdity of this view (p. 6). Of Albrechts's nine propositions, four are either erroneous or doubtful, one irrelevant, the remainder of no importance for the problem at issue. "The entire question," concludes Professor Bartels, "is wrongly put; it is, in my opinion, idle to debate, which of the two sexes of a single class of mammals is of 'lower' rank; moreover, we could, if we so desired, urge the more powerful masticatory apparatus of man, or, following O. Schultze, his larger face in proof of the contrary assertion." Professor Schultze, who emphasizes the relatively childlike character of woman, is indeed careful to refrain from drawing the inference that for this reason man is anatomically superior. It is true that woman, like the new-born infant, has a relatively long trunk, short legs and a rather large head, but, as Schultze points out, any argument for inferiority on such grounds proves a two-edged sword: for, by virtue of his longer extremities and smaller head, man approaches the ape type in greater measure than does his mate.[2] Schultze, who is by no means an adherent of feminism, arrives at the general conclusion that man and woman are fundamentally different organisms, but of equal biological perfection. This is likewise Bartels's summing up of the situation.[3] The fact that these authors nevertheless contend for a differentiation of function because of the anatomical differences need not concern us in this connection.

One point that continues to be urged with much insistency and much lack of intelligence is the inferior size of woman's brain, for in the popular mind intellect and brain weight are closely associated. It is therefore worth while to consider this subject at somewhat greater length.

It is true that the *absolute* weight of man's brain is greater than woman's in every people among whom the comparison has been made. Thus, a large series of English brains shows an average of 1325 g. for the males and of 1,183 for the females; while in a Saxon series male and female brains average 1,355 and 1,223, respectively. A corresponding result is obtained when the brains are compared for cubic capacity rather than for weight: a Bavarian series of 100 male, and an equal number of female, brains yielded average capacities of 1,503 and 1,335 c.c., respectively. In short, the *absolute* size of man's brain does exceed that of woman.[4]

However, it is equally true that the absolute size of an elephant's or

[1] Leipzig, 1913.

[2] "Das Weib in anthropologischer Betrachtung," Würzburg, 1906, p. 20 *f.*

[3] *Op. cit.*, p. 55.

[4] See Bartels, *op. cit.*, pp. 34–35.

whale's brain considerably exceeds that of the male human brain, the weight of the elephant's being from 4,100 to 4,800 g., and that of the whale from 1,900 to 2,800 g. Hence it would seem rash to attach much importance to absolute brain size in comparing male and female intelligence. This skepticism is supported by the individual differences in the brain weight of men as compared with concomitant individual differences in intellect. While it is true that distinguished men often have a brain of more than average size, this is by no means uniformly the case. Noted scientists have been known to fall appreciably below the mean, while persons of moderate ability have turned out to possess enormous brains. In Waldeyer's series the two extremes, 900 and 2,000 g., were found to belong to two mentally quite normal men.

Abandoning the comparison on this basis, we may investigate the *relative* brain weights, *i. e.*, the weight of the brain in relation to the total weight of the body. But here we get the result that woman has a relatively larger brain than man. While the ratio of male and female body weight is as 100 : 83, the brain weights stand in the ratio of 100 : 90. Schultze has calculated the proportion of brain and body weight in man and woman according to the determination of various scholars, and finds a uniform difference in favor of woman. Thus, Schwalbe sets man's average brain weight at 1,375 g., woman's at 1,245 g.; and man's total weight at 65,000 g., and woman's at 55,000 g. This yields a proportion of 1 : 47.47 for man and of 1 : 44.17 for woman.

Can we legitimately infer from these undoubted facts that woman is intellectually superior to man? Hardly, if we draw upon corresponding data from the animal kingdom at large. For then we discover that the human species as a whole is surpassed by the rat, that the mole occupies an intermediate position between man and woman, and that the elephant has a very small relative brain weight. The comparison on this basis is not wholly worthless, for we find that of equally heavy animals the biologically higher type has a relatively heavier brain, and that of two closely related and presumably equally intelligent animals (such as the lion and the cat) the smaller invariably has a greater relative brain weight. It has been suggested with some plausibility that woman's superior relative brain weight is an illustration of the general rule last-mentioned.

What conclusion, then, can be drawn from the facts of brain weight as to the superior mental organization of either sex? Obviously, the only sane inference is that such superiority on either side is quite unproved. Some correlation between brain and intelligence undoubtedly exists; but not in the sense that the size of the brain fully determines intelligence. Bartels's summing up of the situation seems the only warrantable one: so far as we can infer anything from the brain weight of man and woman there is presumably equality of mental ability.[5]

[5] Plotz-Bartels, *op. cit.*, p. 48.

The Psychological Data.—Let us now turn to the argument from psychology. Formerly it was held by men of science and laymen alike that women were mentally inferior to men, on the average; that if the mental abilities of all men and of all women could be averaged separately the result would show a great advantage in favor of men. Exact experiment and class-room experience, however, have led many men of science to abandon the hypothesis that women are on the average mentally inferior to men.

It should be noted that the laboratory experiments purporting to establish sex differences are frequently without bearing on the question of differences in the higher mental processes, and that perfect correlation between efficiency in laboratory tests and efficiency in normal pursuits has not been established. Indeed, Heymans, a careful and conscientious thinker, in his monograph on feminine psychology[6] falls back almost entirely on the direct estimates of university professors as to their men and women students. To be sure, his informants, on the whole, support the time-honored view that women are more industrious, but lack creative power and independence of thought, yet, as Heymans himself recognizes, these judgments may have been largely affected by the judges' initial bias. That this is indeed so is suggested by a comparison of equally offhand judgments by various scholars not cited by Heymans. Thus, Paul Bartels[7] is convinced that the average woman is as competent as the average man, whether at the chessboard or in politics, in science or at the stock exchange, or wherever else in life activity depends predominantly on the intellect. Her great inferiority appears, according to this writer, where efficiency is the result of a well-developed personality: she fails as a leader of crowds or captain of a ship, in poetry, as a physician, as a teacher and leader of boys, etc. In striking contrast to this view stands that of Forel, who considers women and men on a par emotionally, men superior intellectually, and women superior in point of volition. In the face of such disagreement, we may well doubt whether the time has come for a definite statement as to the psychological equipment of woman as compared to man. To revert to the method employed by Heymans, it is interesting to note that a number of American professors who have answered Professor Sedgwick's article in the *New York Times* find no inferiority on the part of their female students. The general change of attitude noticeable on this subject in academic circles gives at least presumptive evidence to the effect that the older opinion was a doctrine of more or less rationalized folk-belief without adequate foundation in fact.

Nevertheless, it is true that woman's intellectual achievement as recorded in history has been inferior, and even scholars who admit the

[6] "Die Psychologie der Frau."

[7] *L. c.*, p. 48.

equality of man's and woman's intellectual endowment now seek to explain this fact on the score of alleged greater male variability.

About a century ago the anatomist Meckel in his "Manual of Descriptive and Pathological Anatomy" concluded on pathological grounds that the human female was more variable than the human male; and he thought that, "since woman is the inferior animal, and variation a sign of inferiority, the conclusion is justified." Later, when variability came to be regarded as a sign of superiority and as a trait affording the greatest hope for progress, anatomists and naturalists arrived at the conclusion that the male is more variable. Men of science who had gone so far as to take the stand that women are *on the average* equally able with men, now inferred from the alleged greater anatomical variability of males that males must also be mentally more variable, and declared women's failure in intellectual achievement to be due to this fact.

Unfortunately for this theory of inherently greater male variability, however, there appears to be no support for it in precise data. Karl Pearson, in his "Variation in Man and Woman" (1897), showed that when anatomical measurements of adults are treated with proper statistical precision, "there is no evidence of greater male variability, but rather of a slightly greater female variability." More recently Montague and Hollingworth[8] have shown from a study of 2,000 newborn infants that there is no demonstrable difference in variability between the sexes at birth. As for mental variability, the precise data at present available have been summed up by Leta S. Hollingworth[9] in a critique recently published. No proof of greater male variability in mental traits can be found in the scant and inconclusive data available on the subject. The theory exists, but the evidence does not.

Yet it is possible to admit equal endowment and equal variability and still to regard as impossible equal achievement on the part of woman. The traditions and tales of savages are replete with the primitive superstitions that center round the functional periodicity of women. And the literature of the nineteenth and twentieth centuries is replete with dogmatic assertions respecting the same subject. A long and patient search through this literature brings to light a veritable mass of conflicting statements by men of science, misogynists, practitioners, and general writers as to the dire effects of periodicity on the mental and physical life of women; but the search reveals scarcely a single fact upon which the earnest, but critical, seeker after truth can lay his hand and say, "Here is a point established." Men eminent in their professions are found announcing the most dogmatic and contradictory notions. Unfortunately for the scientifically minded, they fail, for the most part, to give any hint of the methods by which they arrive at their

[8] Helen Montague and Leta S. Hollingworth, "The Comparative Variability of the Sexes at Birth," *Amer. Jour. of Sociology*, 1914.

[9] Leta S. Hollingworth, "Variability as Related to Sex Differences in Achievement," *Amer. Jour. Sociology*, 1914.

conclusions, usually prefacing their remarks merely with the convenient phrase, "It is very well known." It is certain, at all events, that they did not arrive at their conclusions by introspection; and it scarcely seems likely that much trustworthy information will be accessible on this subject till women have prosecuted their own researches into it. As in the case of variability, the most recent and thorough study, in fact the only precise study, made as to the effects of school work on the periodic function fails utterly to confirm theory. A. E. Arnold,[10] who made the study, announces as his conclusion, after closely following up the records of over 1,000 women over eighteen years of age during two years of college work, that "all effects thus far observed have been in the direction of improvement."

It is amusing to note how every sex difference that has been discovered or alleged has been interpreted to show the superiority of males. When students of institutional statistics discovered that there are more males among inmates of idiot asylums, and supposed this to mean that there must be more males than females among the feeble-minded, this apparently unfavorable fact was at once interpreted as confirmatory evidence of greater male variability; and as such it became immediately favorable to the theory of male superiority. Had it been found that there were more females among inmates of idiot asylums, how easily it could have been used as evidence of the general inferior quality of female mind.

Conclusion.—We may now sum up the argument as follows: The restrictions of woman's sphere on the ground that certain occupations are not *natural* for woman because they are not customary feminine occupations in modern civilization, rests on sheer ignorance of history and ethnology, which reveal a very considerable range of activity under varying social conditions. Anatomically, it may definitely be stated that both sexes occupy the same level. A comparison of male and female brains fails to establish the superiority of either sex. With the removal of folk-psychological prejudices, and with the advance of psychological experiment, a corresponding conclusion is gaining ground as to the average mental equipment. And while the scarcity of female geniuses, and corresponding infrequency of epoch-making achievement, has been attributed to greater male variability, a sex difference in variability has never been scientifically demonstrated. Finally, the hackneyed objection, that women are unable to perform work with male efficiency because of their catamenial function, appears as pure dogma. The verdict of present-day science is thus an uncompromisingly negative one: no rational grounds have yet been established that should lead to artificial limitation of woman's activity on the ground of inferior efficiency.

[10] "The Effects of School Work on Menstruation," *Amer. Phys. Ed. Rev.*, 1914.

MYSTICISM IN WAR

By ELSIE CLEWS PARSONS

TO some of us not least among the pungencies, or if you prefer exasperations, of the European war is the spectacle of its leaders appealing to the gods,[1] or rendering them thanks for the victories put down to their credit. The Czar holds up the sacred *ikon* to be gazed upon by his kneeling, worshipful troops. The Kaiser makes speeches and issues proclamations about the motives and purposes of the God of the Fatherland and of his royal house. Even the British recruit is asked to enter into partnership with God.

But Czar and Kaiser are only true to their kingly parts. As for the British recruit, his cooperation might be considered an instance of delegated sovereignty. But all of his sacerdotal sovereignty the English King has not delegated to his subjects. Some of his sacred war functions George IV himself retains. Has he not vowed not to touch a drop of liquor during the war? A vow is of course a religious act. We recall at once in this connection the vow and sacrifice of Jephtha, the leader of the Hebrew army, and we recall the sacrifice of Iphigenia by her royal father.

Agamemnon in this instance performed a very special act of sacrifice—the circumstances were so contrary—but it was the usual thing for a Greek king whenever he set out on a campaign to sacrifice to deity. Fire from the altar of Zeus was carried in the vanguard of the Spartan army until the army reached the frontier. There the King sacrificed again.

In cultures even more primitive than ours or than the Greek the supernatural rôle of chieftancy in time of war may also be seen. Among the Melanesian tribes of New Guinea there are certain chiefs whose principal function is making war magic. The *paiha* chief of the Roro-speaking tribes carries charms of leaves and bark and pieces of broken weapons into battle, and before the warriors set out he doctors them. Approaching a hostile village, the Mekeo *faia* chief spits on a plant called *ofe* and with it in his hand delivers in the air an overhand blow, striking downward in the direction of the enemy's village. He passes the plant under his right leg and again strikes downward, murmuring spells the while to cause the enemy to sleep heavily. Just before reaching the village he crouches on the ground, blocking his ears with his fingers to

[1] I use the plural advisedly—the deity whose building is bombarded can hardly be the same whose aid is invoked to destroy it.

induce deafness in the enemy. Then, as the rush is made, each warrior jumps over the crouching *faia* chief.[2]

Not only are some of the methods of war magical, not only are war leaders the magicians *par excellence* of their people, the heads of the church; but the very motives and impulses of war arise in part from the same kind of association with which magic is likewise concerned, at least, what is called sympathetic magic. Sympathetic magic is due to a sense of participation. Things that have been in contact affect each other both during and after the contact, and like affects like, these are the two leading principles of sympathetic magic. It is an analogous principle of association, an analogous sense of participation which prompts the family vendetta, the tribal feud, the wars of hamlets or hordes and, may I add, the wars of nations or races. The individual's sense of participation in his group, in his family, tribe or nation, is disturbed when any other fraction of the group is disturbed. He himself feels injured when the group in any part suffers injury. He therefore proceeds to protect his nation, his people, his home, *i. e.*, himself by retaliation upon the injurious group or *any part of it*. This "family feeling" or *esprit de corps*, this sense of patriotism, is a purely subjective feeling, and, like all such feelings, it is unconcerned by logical contradictions, it is untested by objective reality—it is, in short, highly mystical.

What is the difference between this kind of mysticism and mysticism ordinarily speaking, between uncritical group feeling and piety? Piety too is non-logical, subjective, craving union, but the union it desires is not with humans, its sense of participation is with deity; so long as that sense is intact, piety is unconcerned about human relations. Piety is unconcerned about human relations in themselves, but, as the sense of union with deity is immensely strengthened by the sense of common worship, the pious are in fact concerned about the body of the faithful. What that body is to consist of is a matter of circumstance. Consider Christianity. Owing to the circumstances of its genesis, Christianity was dissociated from social groups. It was adrift, so to speak, in society. It was lonely. It developed the dogma of the brotherhood of man, quite as mystical a dogma as nationality or any other principle of kinship. But, after two or three centuries, when Christianity was adopted as a state religion, the Christian's gregarious instinct was satisfied in another way; his sense of participation with mankind became superfluous; it began to atrophy. One with his church-state, the Christian rose up against heretic and pagan, his pristine brethren. Warfare with the enemies of the Christian Church but intensified his sense of participation with the Father of Mankind. The Crusades and the In-

[2] May I suggest that the stimulus given before a charge by magic corresponds to the encouraging shibboleth words of a commander in modern war or to the "dope" allotted, according to Jane Addams and Gilbert Murray, before a cruel bayonet charge?

quisition gave Christians a full measure of the sense of union with God, probably the fullest measure they were collectively to have.

For then, in course of time, came the movement historians call nationalism, a movement which subordinated church to state, the faithful to the patriotic, a movement which made of God at most a national hero. To illustrate this subservience of the godhead I can not do better than cite the colloquy between Shatov and Stavrogin in Dostoevsky's novel, "The Dispossessed," and let me cite it at length, for not only does it illustrate the rôle of the gods in nationality, it expresses extremely well that more fundamental mysticism of nationality which, we hold, is the source of international war. Shatov is speaking:

"Nations are built up and moved by another force [a force other than science and reason] which sways and dominates them, the origin of which is unknown and inexplicable: that force is the force of an insatiable desire to go on to the end, though at the same time it denies that end. *It is the force of the persistent assertion of one's own experience,*[3] and a denial of death . . . the seeking of God, as I call it. . . . The object of every national movement in every people and at every period of its existence is only the seeking for its god, who must be its own god, and the faith in Him as the only true god. God is the synthetic personality of the whole people, taken from its beginning to its end." . . . "You reduce God to a simple attribute of nationality," exclaims Stavrogin. "I reduce God to the attribute of nationality?" cries Shatov. "On the contrary, I raise the people to God. And has it ever been otherwise? The people is the body of God. Every people is only a people so long as it has its own god and excludes all other gods on earth irreconcilably. . . . If a great people does not believe that the truth is only to be found in itself alone (in itself alone and exclusively); if it does not believe that it alone is fit and destined to raise up and save all the rest by its truth, it would at once sink into being—not a great people.

A striking portrait, is it not, of the patriotic Christian, the Christian national?

But why is it, I may be asked, that despite Christianity's subjection to nationalism, despite its own peculiarly bloody history, there has persisted in Christendom a belief in the sanctity of human life, a conviction potent enough at times to make for large bodies of heretics like the Lollards, the Anabaptists, or the Quakers, a conviction that is even today a thorn in the flesh of the unmitigated militarist nationalist?

This outcropping conviction, this stubborn feeling, the Christian pacifist likes to date back to the early years of Christianity; but it is, I suspect, pre-Christian, nay prehistoric. It is akin, I suggest, to the horror of blood pollution felt by primitive peoples. It expresses the same aversion to killing another human being that taboos on the savage homicide betray. After a Pima killed an Apache he had to fast for sixteen days, touching neither meat nor salt, nor looking at a fire blaze, nor speaking to a human being. Were he to touch his head or his face with his fingers, his hair would turn white and his face wrinkle. Unless the Natchez who had taken his first scalp abstained from eating flesh and from sleeping with his wife for six months, the soul of the

[3] The italics are mine.

man he had killed would work his death by magic. For three nights after he had clubbed a human being to death the Fijian warrior had to sleep sitting up. In Central Australia the rest of a successful Arunta warrior is very broken. For nights he must lie awake listening to the cry of the little bird his fallen foe incarnates. Any failure to hear the cry would result in paralysis of right arm and shoulder. For a long time after his kill, a Monumbo warrior of New Guinea may touch no one. Were he to touch his wife or children, they would break out with sores. Among the Koita the homicide himself is endangered. He is supposed to grow thin and emaciated. Having been splashed with the blood of his victim, as the corpse rots, the slayer, they believe, wastes away.

The taboos growing out of this New Guinea belief as well as the other taboos on the victorious have been explained by the ethnologist as due to ghost fear. The homicide is subject to haunting by his victim, the simple-minded hold, and so the homicide must be exorcised or purified. However this may be, whatever reasons early man may have given himself, the beliefs and practises I have cited and many others analogous indicate, it seems to me, that very early man *felt* that the killing of other human beings was excessively repugnant;[4] with death in any form he was reluctant to be implicated. Very likely the upset the implication through killing caused him induced in him a special kind of ghost fear. Among the primitive, fear of ghosts or of evil spirits generally accompanies emotional disturbance.

That the killing itself had to be provoked by fear, by great fear, also seems probable, and that aversion to it had to be overcome by co-operation, by the courage inspired by numbers, by gregarious assurances, by social mysticism.[5] Holding then that "human nature" is not murderous, *i. e.*, men do not kill for the fun of killing, I suggest that war has been possible not because, according to the common view, men are naturally warlike, individually bellicose, but because they are naturally fearful and, above all, in their gregariousness highly mystical. Collective fears and uncritical gregarious impulses are thus the data the pacifist propagandist must consider. Expressions of combativeness or aggressiveness are not so much his concern[6] as are expressions of cowardice and of mysticism.

[4] Just as to-day feels the more conservative of the two sexes, and the sex more addicted to death taboos, *i. e.*, to mourning.

[5] Sometimes by specific acts of magic. "When old enough to join the fighting men the Zulu lads were beaten with the leaves of the cocoa-nut palm during a dance and 'medicine' was given to cause them not to care for or have pity upon any one." (*Reports Cambridge Anthropological Expedition to the Islands of Torres Straits*, V., 299. Cambridge, 1904.)

[6] At a recent meeting to organize a "League to Enforce Peace" ex-President Taft said: "So long as nations partake of the frailties of men who compose them, war is a possibility. . . ." And the speaker had here in mind, not individual fearfulness, I think, but individual bellicosity.

THE ORIGIN AND EVOLUTION OF LIFE UPON THE EARTH[1]

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Lecture I. Part III

Biochemical Evolution of Bacteria—Evolution of Protoplasm and of Chromatin—The Fundamental Biologic Law—Chlorophyll and the Energy of Sunlight—Algæ.

Primary Stages of Biochemical Evolution in Bacteria

A BACTERIA-LESS earth and a bacteria-less ocean would soon be uninhabitable either for plants or animals; conversely, it is probable that bacteria-like organisms prepared both the earth and the ocean for the further evolution of plants and animals, and that life passed through a very long bacterial stage.

Owing to their minute size or actual invisibility bacteria are classified less by their shape than by their chemical actions, reactions, and interactions, the analysis of which is one of the triumphs of modern research. In the origin of life they lie half way between the hypothetical chemical pre-cellular stages (pp. 179–189) and the chemistry and definite cell structure of the lowliest plants or algae. The size of bacteria is in inverse ratio to their importance in the primordial and present history of the earth. The largest known are slightly above 1/20 of a millimeter in length and 1/200 of a millimeter in width.[2] The smaller forms range from 1/2000 of a millimeter to organisms on the very limit of microscopic vision, 1/5000 of a millimeter in size, and to the bacteria beyond the limits of microscopic vision, the existence of which is in-

[1] Fourth course of lectures on the William Ellery Hale Foundation, National Academy of Sciences, delivered at the meeting of the academy at Washington, on April 17 and 19, 1916. The author desires to express his special acknowledgments to Professor E. B. Wilson, of Columbia University, Dr. I. J. Kligler, of the American Museum of Natural History, Professor T. H. Goodspeed, of the University of California, and Dr. M. A. Howe, of the New York Botanical Garden, for notes and suggestions used in the preparation of this section.

[2] The influenza bacillus, 5/10 × 2/10 of a micron (1/1000 mm.) in size, and the germ of infantile paralysis, measuring 2/10 of a micron, are on the limit of microscopic vision. Beyond these are the ultra-microscopic bacteria, some of which can pass through a porcelain filter. See Jordan, Edwin O., 1908, pp. 52, 53.

ferred in certain diseases. The chemical constitution of these microscopic and ultra-microscopic forms is doubtless highly complex.

In their power of finding energy or food in a lifeless world the bacteria known as *prototrophic* or "primitive feeders" are not only the simplest known organisms, but it is probable that they represent the survival of a primordial stage of life chemistry. These bacteria derive both their energy and their nutrition directly from inorganic chemical compounds: such types were thus capable of living and flourishing on the lifeless earth even before the advent of continuous sunshine and long before the first chlorophyllic stage (Algæ) of the evolution of plant life. Among such bacteria possibly surviving from Archeozoic time is one of these "primitive feeders," namely, the *Nitroso monas* of Europe.[3] For combustion it takes in oxygen directly through the intermediate action of iron, phosphorus, or manganese, each of the single cells being a powerful little chemical laboratory which contains oxidizing catalyzers, the activity of which is accelerated by the presence of iron and of manganese. Still in the primordial stage *Nitroso monas* lives on ammonium sulphate, taking its energy (food) from the nitrogen of ammonium and forming nitrites. Living with it is the symbiotic bacterium *Nitrobacter,* which takes its energy (food) from the nitrites formed by *Nitroso monas,* oxidizing them into nitrates. Thus these two species illustrate in its simplest form our law of the *interaction of an organism* (*Nitrobacter*) *with its life environment* (*Nitroso monas*).[4]

The discovery of the chemical life of these bacteria marks an advance toward the solution of the problem of the origin of life as important as that attending the long prior discovery of chlorophyll. The prototrophic forms above noted are classed among the *nitrifying bacteria:* they take up the nitrogen of ammonia compounds and oxidize them first into nitrites and then into nitrates. Heraeus and Hüppe (1887) were the first to observe these forms in action in the soils and to prove that pre-chlorophyllic organisms were capable of development, with ammonium and carbon dioxide as their only sources of energy. Eight chemical "life elements" are involved in this process, namely, potassium, phosphorus, magnesium, sulphur, calcium, chlorine, nitrogen, and carbon. This discovery was confirmed by Winogradsky (1890, 1895), who showed that two symbiotic groups existed; one the *nitrite* formers, *Nitroso monas,* and the other the *nitrate* formers, *Nitrobacter.* These bacteria are not only independent of life compounds, but even small traces of organic carbon and nitrogen compounds are injurious to them. Later Nathanson (1902) and Beyjerinck (1904) showed that certain sulphur bacteria possess similar powers of converting ferrous to ferric oxide, and H_2S to SO_2. These organisms are widespread:

[3] Fischer, Alfred, 1900, pp. 51, 104.

[4] Jordan, Edwin O., 1908, pp. 492–497.

Nitroso monas is found in Europe, Asia, and Africa, while *Nitrobacter* appears to be almost universally distributed.

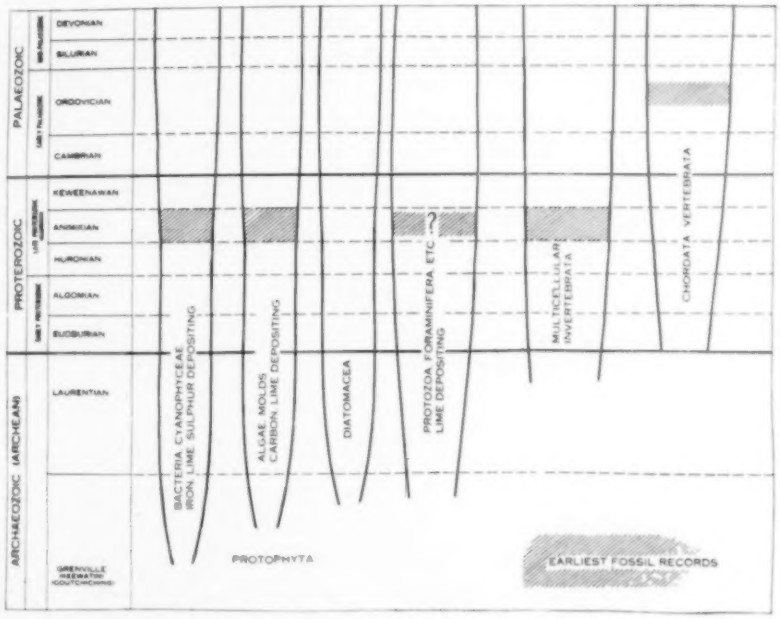

FIG. 1. PRE-CAMBRIAN PHYLÆ OF PLANT AND ANIMAL LIFE.

Such bacterial organisms may have flourished on the lifeless earth and prepared both the earth and the waters for the higher forms of plant life. The relation of the *nitrifying bacteria* to the decomposition of rocks is well summarized by Clarke in the following passage:[5]

> Even forms of life so low as the bacteria seem to exert a definite influence in the decomposition of rocks. A. Müntz has found the decayed rocks of Alpine summits, where no other life exists, swarming with the nitrifying ferment. The limestones and micaceous schists of the Pic du Midi, in the Pyrenees, and the decayed calcareous schists of the Faulhorn, in the Bernese Oberland, offer good examples of this kind. The organisms draw their nourishment from the nitrogen compounds brought down in snow and rain; they convert the ammonia into nitric acid, and that, in turn, corrodes the calcareous portions of the rocks. A. Stützer and R. Hartleb have observed a similar decomposition of cement by nitrifying bacteria. The effects thus produced at any one point may be small, but in the aggregate they may become appreciable. J. C. Branner, however, has cast doubts upon the validity of Müntz's argument, and further investigation of the subject seems to be necessary.

It is noteworthy that it is the *nitrogen derived from waters and soils*, rather than from the atmosphere, which plays the chief part in the life of these organisms; in a sense they represent a pre-carbon stage

[5] Clarke, F. W., 1916, p. 485.

of chemical evolution, also adaptation to an earth and water environment rather than to an atmospheric one.

In our study of the chemistry of the lifeless earth it has been shown how the life elements essential for the energy and nutrition of the nitrifying bacteria, namely, sodium, potassium, calcium and magnesium, with potassium nitrite and ammonium salts as a source of nitrogen, were probably accumulated in the waters, pools and soils. These bacteria were at once the soil-forming and the soil-nourishing agents of the primal earth; they throve in the presence of energy-liberating compounds of extremely primitive character. It is important to note that water and air are essential to vigorous ammonium reactions, whether at or near the surface. In arid regions at the present time the ammonifying bacteria do not exist on the dry surface rocks but act vigorously in the soils, not only at the surface, but also in the lower layers at depths of from six to ten feet where moisture is constant and the porous soil well aerated,[6] thus giving rise to a nitrogen-nourished substratum which explains the deep rooting of desert-dwelling plants.

A second point of great significance is that these nitrifying organisms are *heat-loving* and *light-avoiding;* they are dependent on the heat of the earth or of the sun, for, like all other bacteria, they carry on their activities best in the absence of sunshine, direct sunlight being generally fatal. The sterilizing effect of sunlight is due partly to the coagulation of the bacterial colloids by the rays of ultra-violet light. The sensitiveness of bacteria to sunlight cannot, however, be used as an argument against their geologic antiquity; on the contrary, their undifferentiated structure and their ability to live on inorganic foodstuffs *even without the aid of sunshine* seem to favor the idea that they represent a very primitive form of life.[7]

The great antiquity even of higher forms of bacteria feeding on atmospheric nitrogen is proved by the discovery, announced by Walcott[8] in 1915, of a species of pre-Paleozoic fossil bacteria attributed to "*Micrococcus*" but probably related rather to the existing *Nitroso coccus* which derives its nitrogen from ammonium salts. The *Nitroso coccus* is the form found in this country corresponding to the *Nitroso monas* of Europe. Its mode of life is identical with that of the *Nitroso monas*. These fossil bacteria were found in a section of a chlorophyll-bearing algal plant from the Newland limestone of the Algonkian of Montana, the age of which is estimated to be about thirty-three million years. They point to a very long antecedent stage of bacterial evolution.

[6] Lipman, Charles B., 1912, pp. 7, 8, 16, 17, 20.

[7] I. J. Kligler.

[8] Walcott, Charles D., 1915, p. 256.

In the section (Fig. 2, *A*) shown by the arrow, there is a little chain of cells closely similar to those in the existing species of *Azotobacter,* an organism that fixes atmospheric nitrogen and converts it into a form utilizable by the plant. It is related to the *Nitroso coccus, Nitroso monas* and *Nitrobacter,* and lives on simple salts with mannite $(C_6H_{14}O_6)$[9] as a source of carbon.

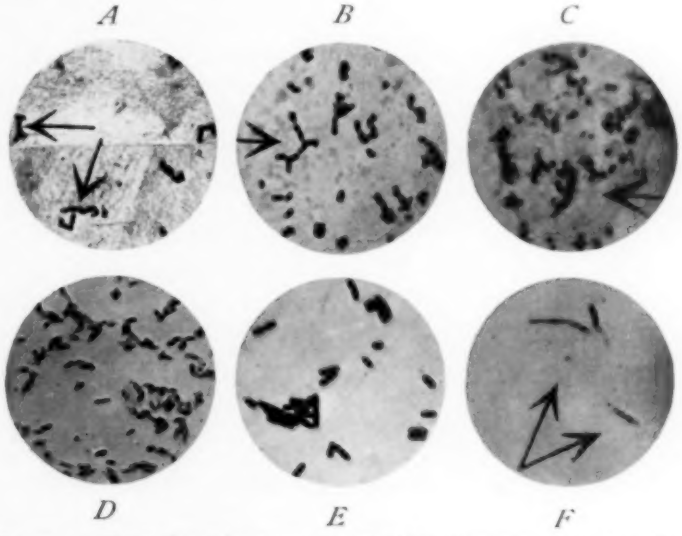

FIG. 2. *A.* Fossil bacteria from the Newland limestone (Algonkian) (after Walcott). *B.* Nitrifying bacteria found in soil. The arrow indicates a chain structure similar to that of Walcott's fossil bacteria. *C.* Nitrifying bacteria found in soils—a more complex type than the above. *D.* Nitrogen-fixing bacteria from the root nodules of legumes. Note the granular structure. *E.* Denitrifying bacteria found in soil and water. *F.* Bacteria stained to bring out the chromatin granules.

It was only after the chlorophyllic carbon-storing true plants had evolved that the second great group of nitrifying bacteria arose to develop the power of storing the *nitrogen of the atmosphere* through life association or symbiosis with plants, and of deriving their carbon, not from inorganic compounds, but from the carbohydrates of plants. Such users of atmospheric nitrogen and plant carbon include three general types: *B. radicicola,* associated with the root formation of legumes, *Clostridium* (anaerobic), and *Azotobacter* (aerobic).[10]

The gradual evolution of cell structure in these organisms can be partly traced despite their excessively minute size. The cell structure of the Algonkian and of the recent *Nitroso coccus* bacteria (Fig. 2, *A, B*) is very primitive and uniform in appearance, the protoplasm

[9] Mannite is needed by the higher forms of nitrifiers (*Azotobacter*), but not by the primitive types, and was probably not found until plant life flourished.

[10] Jordan, Edwin O., 1908, pp. 484–491.

being naked or unprotected: this primitive structure is also seen in *C*, another type of nitrogen fixer of the soil, which is chemically more complex because it can obtain its nitrogen either from the inorganic nitrogen compounds or from the organic nitrogen compounds (amino acids, proteins) which are fatal to the *Nitroso monas* and the *Nitrobacter* forms. The arrow points to a group of rods similar in appearance to those in *B*. A higher stage of granular structure appears in *D*, a nitrogen-fixer from the root nodules of legumes, which like *B* and *C* lives on inorganic chemical compounds but draws upon the atmosphere for nitrogen and upon sugar for its carbon: we observe an uneven granular structure in this cell. This may be an illustration of an early type of parasitic adaptation. The next type of bacterium (*E*) is a *denitrifier,* which derives its oxygen from the nitrates, reducing them to nitrites and free nitrogen and ammonia. A further stage of structural and chemical evolution is seen (*F*) in four elongated bacteria, each showing a rod-like but cellular form with a deeply staining chromatin or nuclear mass: the arrows point to cells showing these chromatin granules. This organism is chemically more complex in that it can secrete a powerful tryptic-like enzyme which enables it to utilize complex polypeptids and proteins (casein). Also it is an obligatory aerobic type, being unable to function in the absence of free oxygen.

It seems that the early course of evolution was in the line of developing a variety of complex molecules for performing a number of metabolic functions, and that the visible cell differentiation came later.[11] Step by step the chemical evolution and addition of increasingly complex actions, reactions, and interactions appears to correspond broadly with the structural evolution of the bacterial organism in its approach to the condition of a typical cell with its cell wall, protoplasm and chromatin nucleus. To sum up, the existing bacteria exhibit a series of primordial phases in the capture, storage and utilization of energy, and in the development of products useful to themselves and to other organisms and of by-products which cause interactions in other organisms. With the simplest bacteria which live directly on the lifeless world we find that most of the fundamental chemical energies of the living world are already established, namely,

(*a*) the protein and carbon storage, the primary food supply of the living world;

(*b*) the colloidal cell interior, with all the adaptations of colloidal suspensions, including

(*c*) the stimulating electric action and reaction of the metallic on the non-metallic elements; for example, the accelerations by iron, manganese, and other metals. Some bacteria carry positive, others negative ion charges;

[11] I. J. Kligler.

(*d*) the catalytic or enzyme action, both within and without the organism.

Thus the chemical composition of bacteria is analogous to that of the higher plant and animal cells, but no chlorophyll and no cellulose is found.

Bacterial suspensions manifest the characteristics of colloidal suspensions, namely, of fluids containing minute gelatinous particles which are kept in motion by molecular movement: these colloidal substances have the food value of protein and form the primary food supply of many Protozoa, the most elementary forms of animal life. Enzymes of three kinds exist, proteolytic, oxidizing and synthetic.[12] The proteolytic enzymes are similar to the tryptic enzymes of animals, being able to digest only the proteoses and amino acids but not the complex proteins. Powerful oxidizing enzymes are present but their character is not known. Synthetic enzymes must also exist though as yet there is no positive information concerning them. Like other forms of life, bacteria need oxygen for combustion in their intracellular actions and reactions; but free oxygen is not only unnecessary but actually toxic to the anaerobic bacteria, discovered by Pasteur in 1861, which derive their oxygen from inorganic and organic compounds. There is, however, a transitional group of bacteria, known as the *facultative anaerobes*, which can use either free, or combined oxygen, thus forming a link to all the higher forms of life in which free oxygen is an absolute essential. There is a group of the higher spore-forming bacteria which must have free oxygen. These constitute probably the last stage in bacterial evolution and form the link to the higher forms.

Armed with these physico-chemical powers, which may have been acquired one by one, the primordial bacteria mimic the evolution of the higher plant and animal world by an adaptive radiation into groups which respectively seek new sources of energy either directly from the inorganic world, or parasitically from the developing organic bacterial and plant foods in protein and carbohydrate form, the different groups living together in large communities and interacting chemically upon one another by the changes produced in the environment. For example, the iron bacteria discovered by Ehrenberg in 1838 obtain their energy from the oxidation of iron compounds, the insoluble oxide remaining stored in the cell and accumulating into iron as the bacteria die.[13] In general the beds of iron ore found in the pre-Cambrian strati-

[12] I. J. Kligler.

[13] It is claimed that iron bacteria play an important part in the formation of numerous small deposits of bog-iron ore and it seems possible that their activities may be responsible for extensive sedimentary deposits as well. Further, the fact of finding iron bacteria in underground mines opens the possibility that certain underground deposits of iron ore may have been formed by them. Harder, E. C., 1915, p. 311.

fied rocks, which have an estimated age of sixty million years, are believed to be of bacterial origin. Sulphur bacteria similarly obtain their energy from the oxidation of hydrogen sulphide.

Bacteria thus anticipate the plant world of algæ, diatoms and carbon-formers, as well as the animal world of protozoa and mollusca, by playing an important rôle in the formation of the new crust of the earth. This is observed in the primordial limestone depositions composed of calcium carbonate formed by bacterial action on the various soluble salts of calcium present in solution in sea-water, a process exemplified to-day[14] in the Great Bahama Banks where chalk mud is now precipitated through accumulation by *B. calcis*. Doubtless in the shallow continental seas of the primal earth such bacteria swarmed, as in the shallow coastal seas of to-day, having both the power of secreting and precipitating lime and, at the same time, of converting nitrogen combinations. In the warm oceanic waters the amount of lime deposited is larger and the *variety* of living forms is greater; but the *number* of living forms which depend for food on the algæ is less because the denitrifying bacteria which flourish in warm tropical waters deprive the algæ of the nitrates so necessary for their development. Again, where algal growth is scarce, the protozoic unicellular and multicellular life (plankton) of the sea, which lives upon the algæ, is also less abundant. This affords an excellent illustration of the great law of *the balance of the life environment through the equilibrium of supply of energy*, one aspect of the interaction of organisms with their life-environment. The denitrifying bacteria rob the waters of the energy needed for the lowest forms of plants, and these in turn are not available for the lowest forms of animal life. Thus in the colder waters of the oceans, where the denitrifying bacteria do not exist, the number of living forms is far greater, although their variety is far less.[15]

The so-called luminous bacteria also anticipate the plants and animals in light production,[16] which is believed to be connected with the oxidation of a phosphorescing substance in the presence of water and of free oxygen.

The parasitic life of bacteria began with their symbiotic relations with other bacteria, and was extended into intimate relations with the entire living world. The number of these organisms is inconceivable. In the daily excretion of a normal adult human being it is estimated that there are from 128 billion to 33 trillion bacteria, which would weigh approximately 5 5/10 grams when dried, and that the nitrogen in this dried mass would be about 0.6 gram, constituting nearly one half the total intestinal nitrogen.[17]

[14] Drew, George H., 1914, p. 44.
[15] Pirsson, Louis V., and Schuchert, Charles, 1915, p. 104.
[16] Harvey, E. Newton, 1915, pp. 230, 238.
[17] Kendall, A. I., 1915, p. 209.

Evolution of Protoplasm and Chromatin, the Two Structural Components of the Living World

It is still a matter of controversy[18] whether any bacteria, even at the present time, have reached the evolutionary stage of the typical cell with its cell wall, its contained protoplasm and its distinct nuclear form and inner substance known as chromatin. Some bacteriologists (Fischer) maintain that bacteria have neither nucleus nor chromatin; others admit the presence of chromatin but deny the existence of a formal nucleus; others contend that the entire bacterial cell has a chromatin content; while still others claim the presence of a distinctly differentiated nucleus containing chromatin. Most of them, however, are agreed as to the presence in bacteria of granules of a chromatin nature, while they leave as an open question the presence or absence of a structurally distinct nucleus. This conservative point of view is borne out by the fact that all the common bacteria have been found to contain *nuclein*, the specific nuclear protein complex; and is also sustained by the fact that the lowliest plants, the blue-green algæ (Cyanophyceæ), contain neither definitely formed nuclei nor chromatin bodies,[19] and are thus regarded as intermediate between bacteria and the higher green algæ (Chlorophyceæ).

It is also a matter of controversy among bacteriologists as to the very important question whether protoplasm or chromatin is the more ancient. Cell observers (Boveri, Wilson, Minchin), however, are thoroughly agreed on this point. Thus Minchin is unable to accept any theory of the evolution of the earliest forms of living beings which assumes the existence of forms of life composed entirely of protoplasm without chromatin.[20] All the results of modern investigations—the combined results, that is to say, of cytology and protistology—appear to him to indicate that the chromatin-elements represent the primary and original living units or individuals, and that the protoplasm represents a secondary product. As to whether chromatin or protoplasm is the more ancient, Boveri suggests that true cells arose through symbiosis between protoplasm and chromatin, and that the chromatin elements were primitively independent, living symbiotically with protoplasm. The more probable view is that of Wilson, that chromatin and protoplasm are coexistent in cells from the earliest known stages, in the bacteria and even probably in the ultra-microscopic forms.

The development of the cell theory after its enunciation in 1838 by Schleiden and Schwann followed first the differentiation of protoplasmic structure in the cellular tissues (histology). Since 1880 it has taken a new direction in investigating the *chemical and functional*

[18] I. J. Kligler.
[19] Loeb, Jacques, 1906, p. 106.
[20] Minchin, E. A., 1916, p. 32.

FIG. 3. CELL FORMS. *A. Achromatium*, a bacteria-like organism with diffused nucleus. *B.* Young ovarian egg of a sea-urchin. *C.* Ovarian egg of a sea-urchin. *D.* Root-tip of an onion. *E.* Embryo of *Sequoia sempervirens*. The mother-cells undergoing division. Two spindles of the reduction-division are shown.

separation of the chromatin. As protoplasm is now known to be the *expression*, so chromatin is now known to be the *seat* of heredity which Nägeli (1884) was the first to discuss as having a physico-chemical basis; the "idioplasm" postulated in his theory being realized in the actual structure of the chromatin as developed in the researches of Hertwig, Strasburger, Kölliker, and Weismann, who independently and almost simultaneously (1884, 1885) were led to the conclusion that the nucleus of the cell contains the physical basis of inheritance and that the chromatin is its essential constituent.[21] In the development from unicellular (Protozoa) into multicellular (Metazoa) organisms the chromatin is distributed through the nuclei to all the cells of the body, but Boveri has demonstrated that all the body cells lose a portion of their chromatin and only the germ cells retain the entire ancestral heritage.

Chemically, the most characteristic peculiarity of chromatin, as contrasted with protoplasm, is its phosphorus content.[22] It is also distinguished by a strong affinity for certain stains which cause its scattered or collected particles to appear intensely dark. Nuclein, which is probably identical with chromatin, is a complex albuminoid substance rich in phosphorus. The chemical, or molecular and atomic, constitution of chromatin infinitely exceeds in complexity that of any other form of matter or energy known. As intimated above (pp. 7, 8) it not improbably contains undetected chemical elements. Experiments made by Oskar, Gunther, and Paula Hertwig (1911–1914) resulted in the conclusion that in cells exposed to radium rays the seat of injury is chiefly, if not exclusively, in the chromatin:[23] these experi-

[21] Wilson, E. B., 1906, p. 403.
[22] Minchin, E. A., 1916, pp. 18, 19.
[23] Richards, A., 1915, p. 291.

ments point also to the separate and distinct chemical constitution of the chromatin.

The principle formulated by Cuvier, that the distinctive property of life is the maintenance of the individual specific form throughout

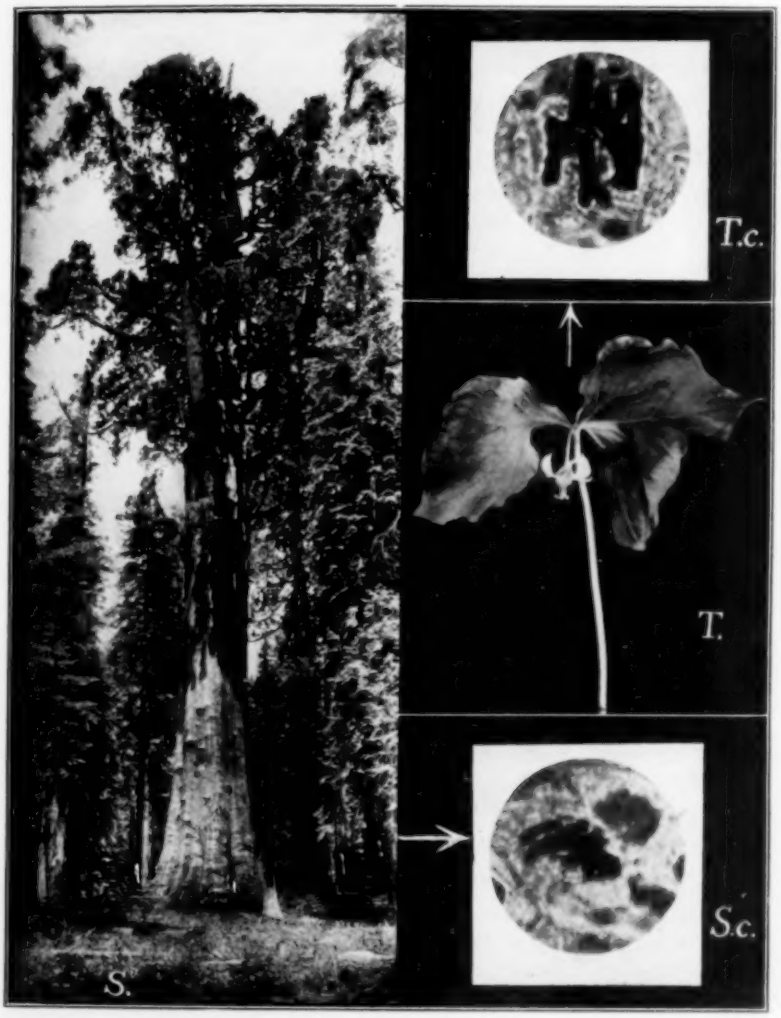

FIG. 4. *S. Sequoia Washingtonia* or *gigantea*. *Sc.* Cell of *Sequoia sempervirens*, showing the chromosomes (chromatin bodies). *T. Trillium*. *Tc.* Cell of *Trillium sessile*, var. *giganteum*, showing the chromosomes in the same phase and with the same magnification as in the cell of Sequoia (*Sc.*).

the incessant changes of matter which occur in the inflow and outflow of energy, acquires wider scope in the law of the continuity of the germ plasm (*i. e.*, chromatin), announced by Weismann in 1883, for it is in

the chromatin that the ideal form is not only preserved, but through subdivision carried into the germ cells of all the present and succeeding generations. The continuity of life since it first appeared in Archeozoic time is the continuity of the physico-chemical energies of the chromatin; the development of the individual life is an unfolding of the energies taken within the body under the directing agency of the chromatin; and the evolution of life is essentially the evolution of the chromatin energies. It is in the inconceivable physico-chemical complexity of the chromatin that life presents its most violent contrast to any of the phenomena observed within the lifeless world.

Although each organism has its specific constant in the cubic content of its chromatin, the bulk of this content bears little relation to the size of the individual. This is illustrated by a comparison of the chromatin content of the cell nucleus of *Trillium*, a plant about sixteen inches high, with that of *Sequoia sempervirens*, the giant redwood tree of California, which reaches a height of from 200 to 300 feet and attains an age of several thousand years (Fig. 5). The chromatin content of such a nucleus is measured by the bulk of the chromosome rods of which it is composed. In the sea-urchin the size of the sperm nucleus, the most compact type of chromatin, has been estimated as about 1/100,000,000 of a cubic millimeter or 10 cubic microns in bulk.[24]

Within such a chromatin bulk there is yet ample space for an incalculable number of minute particles of matter. According to the figures given by Rutherford[25] in the first Hale Lecture the diameter of the sphere of action of an atom is about 1/100,000,000 of a centimeter, or 1/10,000,000 of a millimeter, or 1/10,000 of a micron—the unit of microscopic measurement. The electrons released from atoms of matter are only 1/1800 of the mass of the hydrogen atom, the lightest known to science, and thus the mass of an electron would be only 1/18,000,000 of a micron. These figures help us in some measure to conceive of the chromatin as a microcosm made up of an almost unlimited number of mutually acting, reacting and interacting particles; but

[24] E. B. Wilson, letter of June 28, 1916.

[25] It is necessary, observes Rutherford, to be cautious in speaking of the diameter of an atom, for it is not at all certain that the actual atomic structure is nearly so extensive as the region through which the atomic forces are appreciable. The hydrogen atom is the lightest known to science, and the average diameter of an atom is about 1/100,000,000 of a centimeter; but the negatively charged particles known as electrons are about 1/1800 of the mass of the hydrogen atom. . . . These particles travel with enormous velocities of from 10,000 to 100,000 miles a second. . . . The alpha particles produce from the neutral molecules a large number of negatively charged particles called ions. The ionization due to these alpha particles is measurable. . . . In the phosphorescence of an emanation of pure radium the atoms throw off the alpha particles with velocities of 10,000 miles a second, and each second five billion alpha particles are projected. Rutherford, Sir Ernest, 1915, pp. 113, 128.

while we know it to be the physical basis of inheritance and the presiding genius of all phases of development, we can not form the slightest conception of the mode in which the chromatin speck controls the destinies of *Sequoia gigantea* and lays down all the laws of its being for a period of five thousand years.

We are equally ignorant as to how the chromatin responds to the actions, reactions and interactions of the body cells, of the life environment, and of the physical environment, so as to call forth a new adaptive character,[26] unless it be through some catalytic agencies (p. 8). Yet in pursuing the history of the evolution of life upon the earth we may constantly keep before us our fundamental biologic law[27] that evolution lies within four complexes of energies, which are partly visible and partly invisible, namely:

1. The evolution of the physical environment;
2. The individual development of the organism, namely, of its protoplasm controlled and directed by its chromatin;
3. The heredity evolution of the chromatin with its constant addition of new powers and energies;
4. The evolution of the life environment, beginning with the protocellular chemical organisms and such intermediate organisms as bacteria, and followed by such cellular and multicellular organisms as the higher plants and animals.

} Incessant competition, selection, intra-selection (Roux), and elimination between all parts of organisms in their chromatin energies, in their protoplasmic energies, and in their actions, reactions and interactions with the living environment and with the physical environment.

Chlorophyll and the Energy of Sunlight

As bacteria seek their energy in the geosphere and hydrosphere, chlorophyll is the agent which connects life with the atmosphere, collecting the carbon from its union with oxygen in carbon dioxide. The utilization of the energy of sunlight in the capture of carbon from the atmosphere through the agency of chlorophyll marked the second great phase in the evolution of life, following the first bacterial phase. The chief energy elements, nitrogen and (less frequently) carbon, were captured by bacteria through molecule-splitting in the presence of heat, but without the powerful aid of sunlight.

It is the fossilized tissue of plants which leads us to the conclusion that the agency of chlorophyll is also extremely ancient. Near the base of the Archean rocks[28] graphites are observed in the Grenville series

[26] Wilson, E. B., 1906, p. 434.
[27] Osborn, H. F., 1912.
[28] Pirsson, Louis V., and Schuchert, Charles, 1915, p. 545.

and in the Adirondacks. The very oldest metamorphosed sedimentaries are mainly composed of shales containing carbon.

Since the carbohydrates constitute the basal energy supply of the entire plant and animal world,[29] we may examine the process even more closely than we have done above (p. 172). As a reservoir of life energy which is liberated by oxidation, hydrogen exceeds any other element in the heat it yields, namely, 34.5 calories per gram, while carbon yields 8.1 calories per gram.[30] The results of the most recent researches are presented by Wager.[31]

> The plant organ responds to the directive influence of light by a curvature which places it either in a direct line with the rays of light as in grass seedlings, or at right angles to the light as in ordinary foliage leaves. . . . Of the light that falls upon a green leaf a part is reflected from its surface, a part is transmitted, and another part is absorbed. That which is reflected and transmitted gives to the leaf its green color; that which is absorbed, consisting of certain red, blue, and violet rays, is the source of the energy by means of which the leaf is enabled to carry on its work.
>
> The extraordinary molecular complexity of chlorophyll has recently been made clear to us by the researches of Willstätter and his pupils; Usher and Priestley and others have shown us something of what takes place in chlorophyll when light acts upon it; and we are now beginning to realize more fully what a very complex photo-sensitive system the chlorophyll must be, and how much has yet to be accomplished before we can picture to our minds with any degree of certainty the changes that take place when light is absorbed by it. But the evidence afforded by the action of light upon other organic compounds, especially those which, like chlorophyll, are fluorescent, and the conclusion according to modern physics teaching that we may regard it as practically certain that the first stage in any photo-chemical reaction consists in the separation, either partial or complete, of negative electrons under the influence of light, leads us to conjecture that, when absorbed by chlorophyll, the energy of the light-waves becomes transformed into the energy of electrified particles and, that this initiates a whole train of chemical reactions resulting in the building up of the complex organic molecules which are the ultimate products of the plant's activity.

Chlorophyll absorbs most vigorously the rays between B and C of the solar spectrum,[32] which are the most energizing; the effect of the rays between D and E is minimal; while the rays beyond F again become effective. As compared with the primitive bacteria in which nitrogen figures so largely, chlorophyllic plant tissues consist chiefly of carbon, hydrogen, and oxygen, the chief substance being cellulose ($C_6H_{10}O_5$),[33] while in some cases small amounts of nitrogen are found, and also mineral substances, potassium, magnesium, phosphorus, sulphur, and manganese. On the contrary, it is the invariable presence of nitrogen

[29] Moore, F. J., 1915, p. 213.
[30] Henderson, Lawrence J., 1913, p. 245.
[31] Wager, Harold, 1915, p. 468.
[32] Loeb, Jacques, 1906, p. 115.
[33] Pirsson, Louis V. and Schuchert, Charles, 1915, p. 164.

which distinguishes the proteins of the bacteria: nitrogen is also a large constituent of animal proteins.

PERCENTAGE OF ELEMENTS IN THE PROTEINS[34]

Carbon	50.0 – 55.0
Hydrogen	6.9 – 7.3
Oxygen	19.0 – 24.0
Nitrogen	18.0 – 19.0
Sulphur	0.3 – 2.4

Closest to the bacteria in structure are the so-called "blue-green algæ" or Cyanophyceæ, found everywhere in fresh and salt water and even in hot springs, as well as on damp soil, rocks, and bark. The characteristic color of the Red Sea is due to a free-floating form of these blue-green algæ which in this case are red. Unlike the true algæ the cell nucleus of the Cyanophyceæ ordinarily is not sharply limited by a membrane, and there is no evidence of distinct chlorophyll-bodies, although chlorophyll is present. Their only method of reproduction is that known as vegetative multiplication, in which an ordinary working cell (individual) divides to form two new individuals. The sinter deposits of hot springs and geysers in Yellowstone Park are attributed to the presence of Cyanophyceæ.[35]

With the appearance of the true algæ the earth-forming powers of life become still more manifest and few geologic discoveries of recent times are more important than those growing out of the recognition of algæ as earth-forming agents. As early as 1831 Lyell remarked their rock-forming powers. It is now known that among the various lower organisms concerned in earth-building, the algæ rank first, the foraminifera second, and the corals third. In a forthcoming work by F. W. Clarke and W. C. Wheeler they remark upon these earth-building activities as follows:

> The calcareous algæ are so important as reef builders, that, although they are not marine invertebrates in the ordinary acceptance of the term, it seemed eminently proper to include them in this investigation. In many cases they far outrank the corals in importance, and of late years much attention has been paid to them. On the atoll of Funafuti, for example, the algæ *Lithothamnium* and *Halimeda* rank first and second in importance, followed by the foraminifera, third, and the corals, fourth.

Algæ are probably responsible for the formation of the very ancient limestones; those of the Grenville series at the very base of the pre-Cambrian are believed to be over 60,000,000 years of age. The algal flora of the relatively recent Algonkian time,[36] together with calcareous

[34] Moore, F. J., 1915, p. 199. Nucleic proteins contain a notable amount of phosphorus as well.

[35] Coulter, John Merle, 1910, pp. 10–14.

[36] Walcott, Charles D., 1914.

bacteria, developed the massive limestones of the Tetons. Clarke observes:

> We are now beginning to see where the magnesia of the limestones comes from and the algæ are probably the most important contributors of that constituent.

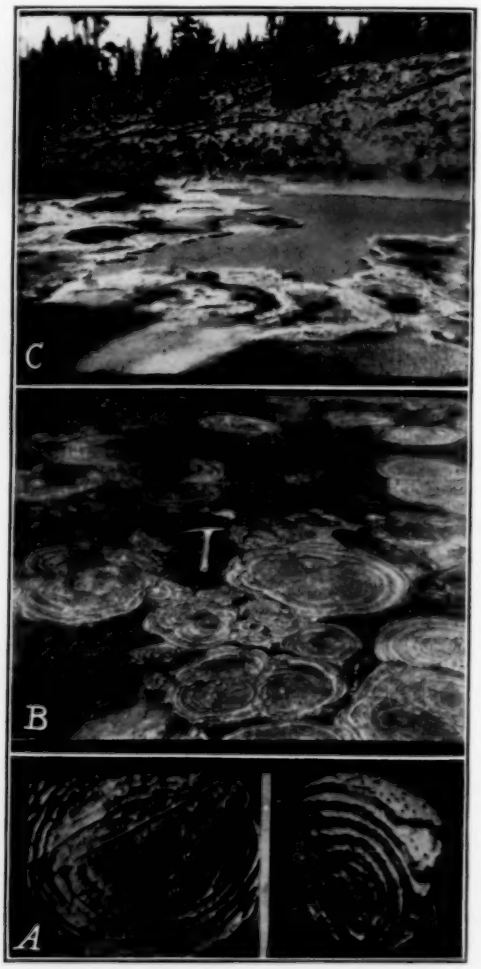

FIG. 5. *A.* Fossil algæ (*Newlandia concentrica, Newlandia frondosa*) from the Algonkian Belt Series of Montana. Walcott. *B.* Fossil calcareous algæ (*Cryptozoon proliferum*) from the Cambrian limestone of Lester Park near Saratoga Springs, New York. *C.* An algal pool near the Great Fountain Geyser, Yellowstone Park. Walcott. Photographed by H. P. Cushing.

Thus representatives of the Rhodophyceæ contribute as high as 87 per cent. of calcium carbonate and 25 per cent. of magnesium carbonate.

Species of *Halimeda,* however, calcified algæ belonging to the very different class Chlorophyceæ, are important agents in reef-building and land-forming, yet are almost non-magnesian.[37]

The Grenville series at the base of the Palæozoic is essentially calcareous, with a thickness of over 94,000 feet, nearly eighteen miles, more than half of which is calcareous.[38] Thus it appears probable that the surface of the primordial continental seas swarmed with these minute algæ, which served as the chief food magazine for the floating protozoa; but it is very important to note that their life is absolutely dependent

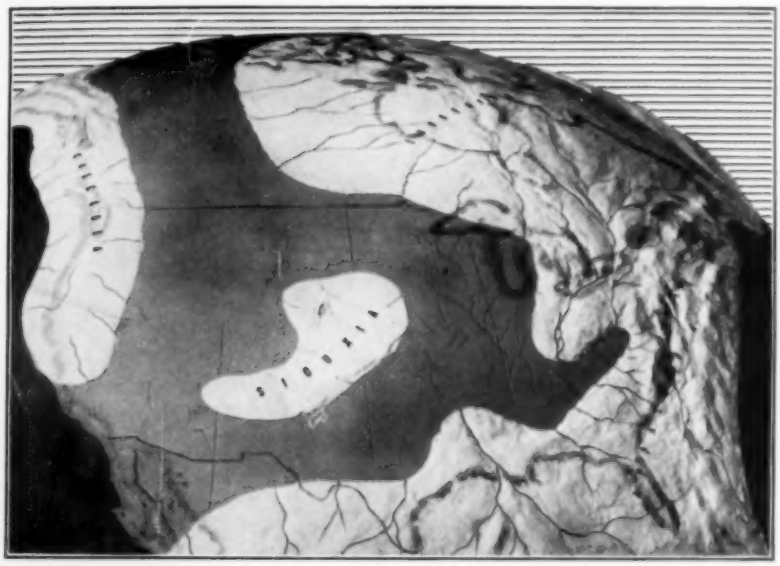

FIG. 6. NORTH AMERICA IN PRE-CAMBRIAN (CROIXIAN) TIME. Detail from globe model by Chester A. Reeds and George Robertson, after Schuchert.

upon phosphorus and other earth-borne constituents of sea-water, as well as upon nitrogen, also earth-borne, and due to bacterial action; for where the denitrifying bacteria rob the sea-water of its nitrogen content the algæ are much less numerous.[39] Silica is also an earth-borne, though mineral, constituent of sea-water which forms the principal skeletal constituent of the shells of diatoms, minute floating plants especially characteristic of the cooler seas which form the siliceous ooze of the sea-bottoms.

(*To be continued*)

[37] M. A. Howe, letter of February 24, 1916.
[38] Pirsson, Louis V., and Schuchert, Charles, 1915, pp. 545, 546.
[39] *Op. cit.,* p. 104.

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THE PROGRESS OF SCIENCE

SCIENTIFIC APPOINTEMNTS UNDER THE GOVERNMENT

A SCIENTIFIC journal must avoid the discussion of party politics, but it is legitimate to point out that the two leading parties have adopted platforms which, as far as their principles go, might almost be interchanged, and have nominated candidates who have much in common, both of them being lawyers, university professors and sons of clergymen. In view of these circumstances it is of interest to those concerned with science that Mr. Hughes in his first campaign speeches should select as one of his two leading issues the appointments by President Wilson to scientific offices under the government. This would not have been a vital political issue a few years ago, and it is certainly gratifying that it should now have become so, more especially as both parties and both candidates profess the same desirable principles and only dispute about the extent to which they have been maintained.

In opening his campaign at Detroit, Mr. Hughes charged the administration with having displaced the scientific heads of the census and of the coast and geodetic survey with men not having scientific qualifications. The word "displaced" is ambiguous and was perhaps intended to be so, and the reply of the secretary of commerce that both men had "voluntarily retired" is also, and it may be purposely, ambiguous. Men familiar with university affairs, like the two candidates for the presidency, know that professors sometimes have their resignations presented to them. It is allowable to say either that Dr. Wilson displaced Dr. Patten as president of Princeton University or that Dr. Patten resigned and was succeeded by Dr. Wilson. As a matter of fact, Dr. Durand's resignation as director of the census was forced, and Dr. Tittman, who was sixty-five years old and in indifferent health, resigned voluntarily from the Coast and Geodetic Survey.

The vulnerable point in the action of the administration is the appointment of their successors. Mr. William J. Harris, appointed director of the census, was chairman of the democratic state committee of Georgia and the appointment appears to have been for political reasons, as has unfortunately so often happened in the bureau of the census, where the extension of civil service rules has been least adequate. E. Lester Jones, when appointed superintendent of the coast and geodetic survey to succeed Dr. Tittman, was deputy commissioner of fisheries. His appointment to that office and his promotion to the head of the survey in the same department appear to have been personal rather than political. He has proved to be an efficient executive, but his appointment to both offices certainly violated the principle that these positions should be held by experts.

It can not, however, be denied that there are two sides to this question. Under modern conditions a distinguished man of science is likely to be a good executive, but the number of scientific men available for a position of this character is limited, and it is by no means certain that it is desirable to divert the skilled expert from his research work to an executive position. Another solution of the problem would be to make the heads of bureaus purely administrative officers, to be filled by men used to administrative work, but for the scientific policy of the bureau

to be decided by a committee of its scientific experts and for the more eminent of these to receive salaries not smaller than that of the executive head.

Mr. Hughes has not pointed out, as an impartial judge might have done, that the two scientific appointments mentioned are the only ones in which the president is open to criticism, or that he is the first president who has officially asked the advice of scientific men on such points. At the meeting of the council of the American Association for the Advancement of Science, held in Washington on April 22, 1913, shortly after President Wilson's installation, the following resolution, proposed by Mr. Cattell, was passed:

> WHEREAS, It is eminently desirable that scientific men especially skilled in their departments be appointed as heads of the scientific bureaus of the government, therefore,
>
> *Resolved*, That a committee of three be appointed to communicate to the President of the United States that it is the opinion of the council of the American Association for the Advancement of Science that a scientific man skilled in meteorology should be selected as the Chief of the Weather Bureau.

The committee waited on the president who requested the secretary of agriculture to consult with the committee of the association. The secretary of agriculture at that time stated that no appointment in the department of agriculture had been made or would be made for political reasons, or even be given to a man who sought the office. The committee of the American Association called the attention of the secretary to the fact that the National Academy of Sciences is by law the scientific adviser of the government, and the president, as far as we are aware for the first time since the law was enacted in 1863, asked the advice of the academy on an appointment. A committee of experts of the academy recommended three men skilled in meteorology and fitted for the office of chief of the weather bureau, and one of these was appointed by the president. In like manner the commissioner of fisheries was appointed from candidates proposed by the American Society of Naturalists and the American Zoological Society. In other cases President Wilson has asked and followed the advice of scientific bodies and scientific men, and his record in this respect is certainly better than that of any of his recent predecessors. We can only hope that he himself or Mr. Hughes, as the case may be, will still further improve this record in the course of the next four years.

A NATIONAL RESEARCH COUNCIL

THE National Academy of Sciences has appointed, at the request of the president of the United States, an organizing committee to make recommendations concerning a national research council of the United States. This committee, which consists of George E. Hale, director of the Mt. Wilson Solar Observatory, chairman, Edwin G. Conklin, professor of zoology at Princeton University, Simon Flexner, director of the laboratories of the Rockefeller Institute for Medical Research, Robert A. Millikan, professor of physics in the University of Chicago, and Arthur A. Noyes, professor of chemistry in the Massachusetts Institute of Technology, have prepared a preliminary statement concerning the plans of the council.

Its purpose is to bring into cooperation existing governmental, educational, industrial and other research organizations, with the object of encouraging the investigation of natural phenomena, the increased use of scientific research in the development of American industries, the employment of scientific methods in strengthening the national defence, and such other applications of science as will promote the national security and welfare.

The council will be composed of leading American investigators and engineers, representing the army, navy, Smithsonian Institution and various scientific bureaus of the government; educational institutions and research endowments; and the research divisions

of industrial and manufacturing establishments. Research committees of two classes will be appointed: central committees, representing various departments of science, comprised of leading authorities in each field, selected in consultation with the president of the corresponding national society; local committees in cooperating institutions engaged in research.

The following plan of procedure is proposed:

1. The preparation of a national inventory of equipment for research, of the men engaged in it, and of the lines of investigation pursued in cooperating government bureaus, educational institutions, research foundations and industrial research laboratories; this inventory to be prepared in harmony with any general plan adopted by the proposed government council of national defence.

2. The preparation of reports by special committees, suggesting important research problems and favorable opportunities for research in various departments of science.

3. The promotion of cooperation in research, with the object of securing increased efficiency; but with careful avoidance of any attempt at coercion or intereference with individual freedom and initiative.

4. Cooperation with educational institutions, by supporting their efforts to secure larger funds and more favorable conditions for the pursuit of research and the training of students in the methods and spirit of investigation.

5. Cooperation with research foundations and other agencies desiring to secure a more effective use of funds available for investigation.

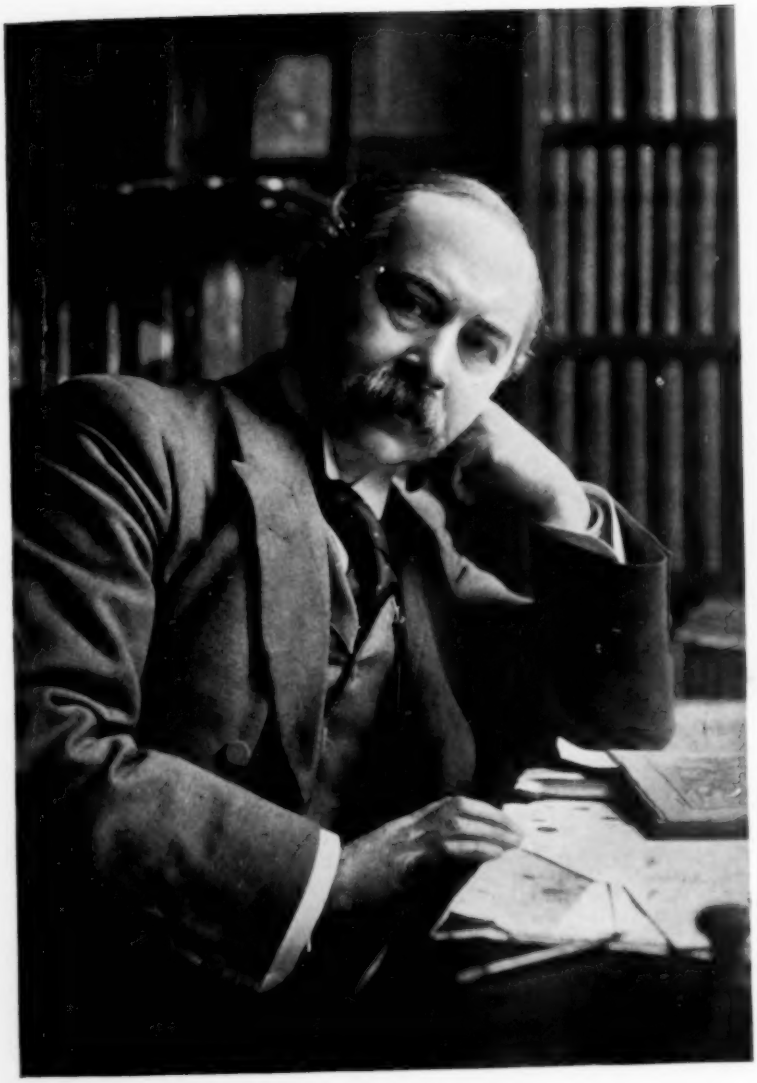
6. The encouragement in cooperating laboratories of researches designed to strengthen the national defence and to render the United States independent of foreign sources of supply liable to be affected by war.

It is not clear why there should be a discrimination between educational institutions and research foundations, so that the former should be aided in securing larger funds and the latter in using their funds more effectively, and some scientific men may think it more desirable to cooperate with other nations in producing supplies where this can be done to the best advantage, rather than to prepare for war. The National Research Council should, however, be able to perform a useful service, more especially in directing public attention to the importance of scientific research for the welfare of the nation and of the world.

THE EPIDEMIC OF INFANTILE PARALYSIS

THERE have been in New York City up to August 20 about 7,000 cases of infantile paralysis and 1,600 deaths and the epidemic has spread to a serious extent in adjacent parts of the state and in New Jersey. The only alleviating circumstance in connection with this disease, which from its ill-understood origin and mode of transmission, produces in these days somewhat the same psychologic effects as smallpox and the plague in past days, is that thorough measures have been undertaken to check the disease and that these may be extended to other diseases which entail an even greater amount of suffering and death than poliomyelitis.

Efforts are also being made in many places to obtain scientific information concerning the disease. Thus at the suggestion of Dr. Haven Emerson, health commissioner of New York City, a conference took place at the College of Physicians and Surgeons, early in August, of which Dr. Simon Flexner was chosen as chairman. A committee was appointed to consider all the phases of laboratory investigation, to suggest subjects and in some instances lines of study in connection with the disease. This committee consists of Dr. Flexner, Professor Ludvig Hektoen, University of Chicago, Professor Hans Zinsser, College of Physicians and Surgeons, New York; Professor Richard M. Pearce, Jr., University of Pennsylvania; Professor James W. Jobling, Vanderbilt University; Surgeon George W. McCoy, director of the hygienic laboratory at Washington, and Dr. Theobald Smith, of the Rockefeller Institute. Another committee was appointed to consider practical measures



SYLVANUS PHILLIPS THOMPSON,
whose death deprives England of one of its most distinguished physicists.

that might apply in the suppression of the epidemic. This committee consists of Dr. Victor C. Vaughan, University of Michigan, chairman; Professor Milton J. Rosenau, Harvard; Dr. William H. Park, department of health, New York City; Dr. Francis W. Peabody, Boston; Dr. John Howland, Johns Hopkins; Dr. Augustus B. Wadsworth, director of the state laboratories, Albany, and Professor Charles C. Bass, Tulane University. The members of the conference were conducted through the infantile paralysis wards of the Willard Parker Hospital and were present at a clinic held there. The research workers will carry with them cultures of the disease and will work out various lines of investigation in their own laboratories. The report of the conference was presented to Dr. Haven Emerson on August 4 and lays stress on:

1. The early recognition and notification of the disease, and
2. The immediate isolation of patients and cases of suspicious illness. Furthermore, on account of incomplete knowledge concerning the disease, measures known to be effective in checking the spread of other infections should be applied and these are, particularly, personal hygiene, cleanliness of person and surroundings, and care of food, which should be thoroughly cooked.

The special problems suggested for study are the following:

1. Methods of culture of the virus of poliomyelitis, with especial reference to corroboration of previous work, to simplification of methods, and to the distribution of the virus in the body of patients.
2. The immunologic reactions of patients, supposed carriers of the virus, and others.
3. The virulence for animals, of the crude virus, in order to determine if possible whether there are any differences in the virus causing outbreaks in different parts of the country as well as to discover, perchance, more susceptible animals for experimental purposes than are now available.
4. The microscopic study of the secretions of the nose and throat and of the intestinal contents of patients suffering from poliomyelitis, persons who have come in close contact with such patients, and others.
5. The transmission of the disease by insects and domestic animals and other possible modes of transmission.
6. The study of practical methods of disinfection.

SCIENTIFIC ITEMS

We record with regret the death of John B. Murphy, the distinguished Chicago surgeon; of William Cole Esty, professor emeritus of mathematics, Amherst College; of William Simon, professor of chemistry at the College of Physicians and Surgeons, Baltimore; of Sir Victor Horsley, the distinguished English surgeon, and of Sir William Ramsay, the eminent British chemist.

The Royal Society of Edinburgh has elected as foreign honorary fellows, Professor D. H. Campbell, professor of botany, Leland Stanford University; General W. C. Gorgas, U. S. Army, and Professor E. C. Pickering, director of Harvard College Observatory.—The Hon. Bertrand Russell, F.R.S., one of the most distinguished English students of philosophy, was recently fined for issuing pamphlets to conscientious objectors to military service and deprived of his lectureship at Trinity College, Cambridge; now it is said he has been refused a passport to visit America to keep his engagement to lecture at Harvard University.

The vocational-educational bill, providing for federal cooperation with the states in promoting agricultural and industrial education, makes an annual appropriation beginning at $500,000 and increasing each year by $250,000 until $3,000,000 is reached, to be apportioned to the states in proportion to their rural population.—The jury in the Surrogates' Court of New York City has declared invalid the will of Amos F. Eno, according to which Columbia University was made the residuary legatee and would receive an amount estimated at over four million dollars. It is understood that Columbia University will seek to obtain a new trial.